HANDBOOK

OF THE

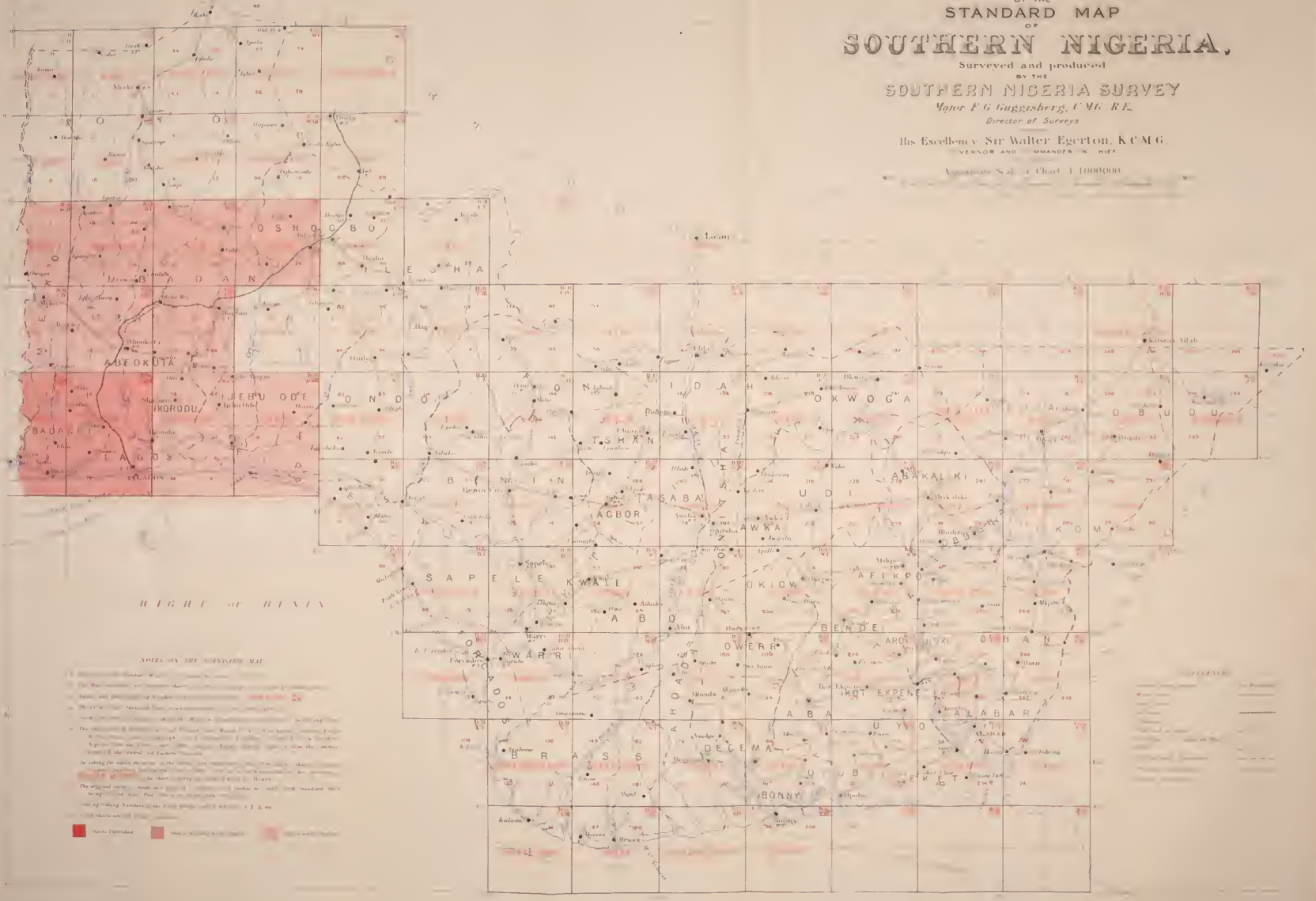
SOUTHERN NIGERIA SURVEY

INDEX CHART
OF THE
FIELD SHEETS AND STANDARD SHEETS
OF THE
STANDARD MAP
OF
SOUTHERN NIGERIA,

Surveyed and produced
BY THE
SOUTHERN NIGERIA SURVEY
Major F G Guggisberg, C M G R E.
Director of Surveys

His Excellency Sir Walter Egerton, K C M G.
VERNOR AND MMANDER N HIEF

Approximate Scale of Chart 1 1000000



RIGHT OF RIVER

NOTES ON THE STANDARD MAP

HIS EXCELLENCY

SIR WALTER EGERTON, K.C.M.G.

GOVERNOR OF SOUTHERN NIGERIA

Under whom the Southern Nigeria Survey was re-organised in 1910

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THE EUROPEAN STAFF, FIRST FIELD SEASON

HANDBOOK

OF THE

SOUTHERN NIGERIA SURVEY

AND

TEXT BOOK

OF

TOPOGRAPHICAL SURVEYING IN TROPICAL AFRICA

BY

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TO THE

COLONIAL SURVEY COMMITTEE

PREFACE.

THIS Handbook contains the Rules and Regulations which govern the Southern Nigeria Survey in the matter of organisation and administration, and also lays down the principles on which the technical details of all Topographical Survey Work are to be executed and in which all Survey pupils are to be instructed.

As a text-book it does not pretend to be complete, but rather to adapt existing systems to what may be fairly described as very difficult local conditions, both climatic and topographical.

Undoubtedly the most satisfactory method of surveying a country is by what may be called "exact" systems, but the more exact the system the greater the cost of survey. Hence, the surveyor must adopt a fair mean between accuracy and cost,—must make a judicious proportionate use of the theodolite and compass, of the level and the aneroid, of the steel band and the human stride,—in short, must cut his coat according to the cloth.

The Chapters on "Field Camps and their Work," "Compass Traverses," are the outcome of several years' practical experience in the survey of British Equatorial Africa. In other respects I have made free use of the *Handbooks of the Survey of India*, and of Lieutenant-Colonel C. F. Close's *Text-Book of Topographical and Geographical Survey*. My sincerest thanks are due to both the foregoing authorities for the valuable assistance received, and also to Captain R. H. Rowe, R.A., for his assistance in the paragraphs on Organisation, to Lieutenant G. G. Waterhouse, R.E., for the Chapter on Base Measurement, and to Lieutenant-Colonel C. F. Close, C.M.G., R.E., and Major W. J. Johnston, R.E., for their advice and criticism.

SOUTHERN NIGERIA SURVEY OFFICE,
CARLTON HOUSE, REGENT STREET.

August 1911.

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FOREWORD.

"It cannot be too strongly impressed on all members of the Department that every consideration should give way to the one great and paramount object of turning out good work, which may be thoroughly relied on by the public, and which will be found on examination in the field to be as accurate as it appears to be on paper. The public service requires the maximum amount of work of the best description; it expects quantity as well as quality; but quantity without quality is of very questionable value; the out-turn should, therefore, on no account be permitted to exceed what can be accomplished with an appropriate degree of fidelity. The surveyor should resist all temptation to gain fictitious credit by departing from the strict line of duty. It may be difficult for him to refrain from injudicious haste when he knows that some of his brother surveyors are working with greater rapidity than himself, and are likely to gain more credit than himself because they happen to have a greater show of work, but his duties appertain to his own work only, and if he is careful to make it as good as possible it will always be a credit to him and to the Department."—(S.I.)

CHAPTER I.

GENERAL ORGANISATION OF, AND REMARKS ON, THE SOUTHERN NIGERIA SURVEY.

1. SOUTHERN NIGERIA is divided into three provinces—the Western, Central, and Eastern. It lies approximately between 4° 15′ and 9° north latitude, and 2° 45′ and 10° 15′ east longitude, and has a total area of 77,260 square miles. Topographically speaking, the colony consists of three main zones or areas, each possessing characteristics which seriously affect the system of survey adopted, viz.:—

Nature of the Colony.

(a) *An Area of Swamp and Mangrove Forest with impenetrable undergrowth*, varying from 20 to 60 miles in width for about 250 miles along the coast-line. This area includes the delta of the Niger, and is intersected with creeks and rivers, the most important of which are the Benin, Forcados, New Calabar, Bonny, and Cross Rivers.

(b) *A Belt of Dense Forest with practically impenetrable undergrowth*, extending from the western to the eastern boundary, and from 50 to 100 miles in width. Its southern edge is about 10 miles from the coast in the Western Province, and thence runs along the north of the mangrove area. Its northern limit is difficult to define exactly, as the belt gradually changes to patches of forest alternating with thick scrub and grass plains approximately along the line Abeokuta, Ibadan, Ondo, Onitsha, Afikpo. The country is generally undulating, with scattered hills, and seldom is a view obtainable without extensive clearing. The forest is intersected with rivers and streams, and the only open spaces are village and farm clearings.

(c) North of the forest belt the country becomes more *open*, gradually developing into park-like country, and thence into open expanses covered with high grass, which is burnt down in December and January. It is generally hilly, especially north of Ondo and on the Cameroons boundary, where the Oban Hills rise to over 3300 feet.

2. In the nine years up to April 1910 the Western Province was covered with a network of traverse lines executed with theodolite and steel band, and checked by observed latitudes and telegraphic longitudes, the latter based on that of Lagos, telegraphically determined from Cape Town. This traverse framework was not satisfactorily complete owing to the absence of records, which naturally detracted from its value, however accurately the work may have been done. By April six sheets of the standard map (scale 1 : 125,000) were published, but it was considered advisable to re-survey the area so

Existing State of Survey, April 1910.

NOTE.—To facilitate cross-references the numbers of the paragraphs are printed in large type on the outer corner of every page.

covered owing to the maps having been compiled in the office and to the absence of sufficiently complete horizontal and vertical frameworks. In this re-survey as much use as possible was made of the old traverse framework, but a trigonometrical framework superseded it in the northern part of the province.

In April 1910 a 1:500,000 map of the Central and Eastern Provinces, compiled by Captain W. H. Beverley, Intelligence Officer, from miscellaneous surveys made by the Survey Department, Captain A. J. Woodroffe, Lieutenants J. P. Moir, L. N. King, and J. G. Hearson, R.E., the Marine and Public Works, District Commissioners, West Africa Frontier Force, etc., was published by Stanford's Geographical Establishment. This map, though lacking an accurate framework, was a valuable compilation, and proved of great value in satisfying the demand for topographical information until the Survey of Southern Nigeria could extend its operations to the two provinces in question.

A 1:1,000,000 sheet of Lagos and Southern Nigeria was printed by the Geographical Section, General Staff, in March 1907, but having been compiled in London, was necessarily incomplete, though forming a good guide to the whole colony.

A trigonometrical survey of the Cameroons boundary between Yola and the Cross River rapids was executed by Major G. F. A. Whitlock, R.E., in 1907-9, and is shown on Captain Beverley's map; and a trigonometrical survey of the Oban Hills by Captain A. J. Woodroffe, R.E., in 1905.

Surveys of the boundaries between Southern Nigeria, Dahomey, and Northern Nigeria were executed by special commissions at various times. The method employed consisted mainly of compass work, checked by observed latitudes and chronometer longitudes. A certain adjustment of the results of these surveys will probably be found necessary, and the lack of boundary pillars and cairns remedied.

On the 1st April 1910 the reorganisation of the Southern Nigeria Survey Department was started by Major F. G. Guggisberg, C.M.G., R.E. Levelling camps took the field in June, stores were obtained from England, the Department divided up into branches, the staff increased by one R.E. officer and six non-commissioned officers, and the *Handbook* written and issued in cyclostyle form to the trigonometrical and nine topographical field camps which took the field between September and November. In November Mr A. Cleminson, the Deputy Director, undertook the reorganisation of the Cadastral Branch, and by the end of the month the Southern Nigeria Survey was working smoothly under the new regulations, although great difficulties had to be overcome owing to the inexperience of the majority of the staff in topographical methods.

3. The objects of the Southern Nigeria Survey are:—

Objects of the Southern Nigeria Survey.

(a) *Topographical.*—To produce as rapidly as possible the standard map of the colony on a scale of 1:125,000 (1·014″=2 miles). When the standard map is completed, to undertake revision surveys, special surveys required by the Government, and to compile smaller scale provincial, district, and school maps.

(b) *Cadastral.*—To supply the Government with township, water supply, and other plans that may be required, and to undertake paying work of delimiting lands and forest reserves. (The work of the Cadastral Branch is dealt with in Part II.)

(c) *Educational.*—To train young natives as professional surveyors.

(d) *Meteorological.*—To supply *matériel* for, and to collect and publish the results of, temperature and rainfall records throughout the colony.

The Standard Map: Description.

4. The standard map of the colony is part of the general map of Africa, scale 1 : 125,000, which is being gradually completed by the Survey Departments of the various British colonies and protectorates, and by the Geographical Section, General Staff, War Office.

The conventional signs, system of printing, etc., used in the Southern Nigeria standard map are, with certain adaptation to local characteristics, founded on the system used in the production of the War Office map of Africa.

The standard map consists of sheets, each half a degree square and each containing an area of about 1182 square miles. The colony extends over the whole or part of eighty-seven sheets, but some of these can be combined with others, so that a total of sixty-four sheets only is anticipated.

The sheets will show all topographical detail in five colours—viz., towns and roads in black ; provincial, district, and concession boundaries in red ; rivers in blue ; forest and agriculture in green ; hills in brown, etc.

The sheets can be joined and mounted as a wall map, or mounted on canvas in folding form, each folding edition covering areas of a size convenient for Commissioners.

General Method of Map Making.

5. (a) It may be accepted as a hard and fast principle that all maps should be completely drawn in the field with the actual features of the ground before the eye of the surveyor. Maps compiled in the office from work done in the field, or from cadastral surveys,—no matter how carefully carried out,—are unsatisfactory and unreliable.

(b) Before a standard map can be produced and published, whether in the survey office or by a publishing firm, various survey operations have to be gone through, and the map built up step by step. In order to assist in understanding the brief description of these steps, a few definitions in general use in the Southern Nigeria Survey are given in para. 6.

(c) To begin with, the accuracy aimed at in carrying out the various processes of construction depends not only on the nature of each individual process but also on the monetary resources of the survey. This last fact is sometimes lost sight of, for accuracy means time and money, and there is no profession in the world in which there is more temptation to enter into minute niceties than that of the surveyor.

The guiding principle of every surveyor, therefore, should be to cut his coat according to the cloth available, an old saying which in this case implies that a fair mean should be struck between the

conflicting demands of accuracy and economy. In the Southern Nigeria Survey accuracy is obtained by the construction of a carefully executed framework which divides the country into blocks of varying size and shape, inside which are localised all errors inherent to the less rigorous systems adopted, for the sake of *economy*, in surveying topographical detail.

(d) The first step in standard map construction is to obtain a rough map of the country. This can usually be compiled from the sketches of expeditionary forces, district commissioners, and explorers, or it may be the result of a reconnaissance survey (para. 6, e).

(e) A general plan of operations is then made, depending on the time and money available and the nature of the country. In surveying a new country it is generally far cheaper to send out the officer, to whom it is intended to entrust the command of the survey, for six months or a year by himself, rather than to land the whole party at once, ignorant of local conditions and topography. But this is a rule which is more honoured in the breach than in the observance.

(f) A framework is then constructed, as described in paras. 7 and 8.

(g) The topographical details of the country are then surveyed, as described in paras. 9 and 10.

(h) The field sheets, *i.e.*, the maps made actually in the field, then go through certain office processes, such as tabulation and correction of names, registration, etc.

(i) The standard map is then produced from the field sheets.

In the Southern Nigeria survey this process is entrusted to Messrs W. & A. K. Johnston, of Edinburgh, to whom the field sheets are taken in each field recess, and by whom the standard map of the colony, described in para. 4, is produced and published.

Survey Definitions.

6. (a) *Geodetic Survey.*—This is a survey executed with the highest degree of refinement for the purpose of determining the form and size of the earth. It does not at present form part of the work of the Southern Nigeria Survey.

(b) *Topographical Survey.*—This is the process of accurately delineating the features of a country, both natural and artificial, with a view to the preparation of a map as complete in all details as the scale used will permit. It includes triangulation, traverse, compass, and plane-table surveys.

(c) *Cadastral Survey.*—A survey to define property boundaries, and to determine the enclosed areas. Includes concession and town surveys, water supply surveys, etc. Usually executed in Southern Nigeria by traverse survey, the nature of the country but rarely permitting of the use of triangulation.

(d) *Geographical Survey.*—The survey of a belt of country with some special object in view, such as the delimitation of an international boundary. It is usually of the nature of a topographical survey, but is sometimes merely a reconnaissance survey.

(e) *Reconnaissance Survey.*—A survey of the nature of a topographical survey, but which for some reason, such as pressure of time or lack of skilled surveyors, is not executed with any high degree of accuracy.

(f) *Supplementary Survey.* (*See* para. 32.)

(g) *Trigonometrical Survey.* (*See* "Triangulation.")

(h) *Triangulation.*—A system of survey by which, starting from a measured base line, the position of a third point can be accurately determined by measuring the three angles of the triangle. Other triangles are formed on the sides of the first triangle, and so on, until the country is covered with triangles of from 1 to 50 miles side, the exact lengths of the sides and the latitudes and longitudes of all the points of the triangles being known. Triangulation is seldom possible in a forest country. Beyond the measurement of the original and check bases, no further linear measurements are made.

(i) *Trigonometrical Station.*—A point at which the theodolite is actually set up in the course of the triangulation survey.

(j) *Intersected Point.*—A point identified on the ground and on paper by intersection with a theodolite from two trigonometrical stations, and a third if possible, but which is not visited either owing to its inaccessibility or other reasons (*see* para. 225). There are several kinds of intersected point, such as points fixed by intersection with a plane table or a compass, but these are respectively defined as such, the term intersected point being held to apply to one fixed by the trigonometrical survey only.

(k) *Traverse Survey.*—A survey made by measuring the bearings and lengths of lines. Largely used in close country, the traverse lines zigzagging through the forest as they follow the course of some winding path or stream. Traverse surveys range from those executed with a high order of accuracy with theodolites and steel bands to those executed with prismatic compass and pacing (*see* "Traverse, Theodolite"; "Traverse, Compass"; and "Traverse, Plane Table").

(l) *Traverse Stations.*—Points on a traverse survey where the traverse line changes direction. Are only of real value when the survey is a theodolite traverse, and for the purpose of identification should be permanently marked on the ground when near a road junction, stream, etc.

(m) *Traverse, Theodolite.*—A traverse survey in which the angles between the traverse lines are measured with a theodolite and the bearings are checked astronomically, the lines being measured with great refinement to secure accuracy. Theodolite traverses are of two classes, viz., primary and secondary (*vide* Chapter V.).

(n) *Traverse, Compass.*—A traverse survey in which the bearings of the lines are measured with a magnetic compass and the lines with a steel band, or by other means. Compass traverses are of five classes, viz., primary, secondary, tertiary, rope, and time, according to the accuracy of the system employed (*see* para. 101).

(o) *Traverse, Plane Table.*—A traverse survey in which the traverse lines are drawn on the plane table by direct observation on the ground and with no measurement of angles. The lines are measured by steel bands. Plane table traverses are of two kinds, viz., primary and secondary (*see* para. 213, Chapter VI.).

(p) *Plane-table Survey.*—A topographical survey executed with a plane table. The plane table consists of a board revolving horizontally on a tripod. On the board is pasted a sheet of paper on which the positions of the trigonometrical points in the vicinity are plotted before the surveyor takes the field. By directing an alidade (*i.e.*, sight-rule) on the actual trigonometrical points and drawing

lines on the paper the surveyor is able to plot his actual position on the ground and to fix its height. It therefore follows that a plane-table survey is only possible in open country.

(q) *Plane-table Fixing.*—The position of the surveyor on the ground which he fixes by rays to at least three known points and identifies on paper. The known points must be fixed points (*see* u), or a previous plane-table fixing (not one of "Single Value").

If the fixing is made from only two known points of the nature of those given above it is unreliable, and is said to be of "Single Value."

(r) *Survey Beacons.*—Permanent marks of stone or metal erected on the ground and marked on the map. Their latitudes and longitudes are filed in the survey office, and their whereabouts can be ascertained from the nearest village headman. Beacons may either mark trigonometrical stations or intersected points, traverse stations, etc., or some known spot which it is advisable to identify.

(s) *Field Sheet.*—The sheet of drawing paper pasted to a plane-table board which the surveyor takes into the field with him, and on which he completely draws the map of the area entrusted to him. The field sheets roughly cover an area a quarter degree square, about 295½ square miles. As a surveyor is usually given an area to survey covering a sheet of the standard map (half a degree square), he takes four of these field sheets with him, each mounted on its own plane-table board. The field sheets are usually on a scale of 1 : 62,500.

(t) *Auxiliary Sheet.* (*See* para. 64.)

(u) *Fixed Point.*—A fixed point is one of which the latitude and longitude have been fixed accurately either by triangulation or theodolite traverse surveys. These points are liable to be slightly in error, but such error would not be plottable on the field sheets. For practical purposes, these fixed points are accepted as being absolutely accurate. They consist mainly of trigonometrical stations, intersected points (not of "Single Value"), and theodolite traverse stations.

Horizontal Framework.

7. The topographical survey of a country is based on a horizontal and a vertical framework executed with great accuracy. The framework of nearly all countries consists of triangulation, but owing to the presence of the mangrove and forest belts mentioned in para. 1 it is necessary to construct the framework of the survey of Southern Nigeria on two systems, viz., triangulation and theodolite traverses.

The system of triangulation adopted is described in Chapter VII., and consists of two classes of work, viz., the main triangulation and the minor triangulation. The base of the main triangulation was measured by Lieutenant G. G. Waterhouse, R.E., in December 1910 with invar wires, and extends for a distance of 10 miles in south-westerly direction from Eruwa towards Abeokuta. The probable error of measurement was less than 1 in 1,000,000. The triangulation is carried first over the northern part of the Western Province with a view to subsequent extension across the northern parts of the Central and Eastern Provinces. Wherever possible the triangulation (either main or minor) will be published southward through the forest, and check bases formed where convenient.

The remainder of the colony is being gradually covered with a framework of theodolite traverses, use being made of some of those already existing in the Western Province (*vide* para. 2). The traverse framework is connected with the triangulation, and is further checked by closed figures, telegraphic longitudes, and observed latitudes. The system of traverse survey is given in Chapter V.

The average linear error of the systems used are probably about :—

Main triangulation . .	1 in 15,000.
Minor triangulation . .	1 in 10,000.
Traverses	1 in 1000 to 1 in 5000.

Vertical Framework.

8. In the triangulated region the vertical framework consists of the trigonometrical heights. A checked line of instrumental levels connects the trigonometrical base to Lagos, and further lines run from convenient points on the triangulation to Calabar, Bonny, and Forcados.

In the traversed region the vertical framework consists of lines of topographical levels run along certain convenient tracks (*see* para. 130).

General System of Topographical Survey.

9. On the completion of a sufficiently checked framework on each sheet of the standard map, a topographical survey party, called a "Field Camp," is sent into the field at the first opportunity to survey and complete the map of the area covered by that sheet.

Regulations for the conduct of the different systems of survey employed in thus filling in the topographical details of the country are given in the chapters on plane-tabling, traversing and compass traversing. Briefly, the systems are as follows:—

(a) *In the Mangrove and Forest Belts.*—Compass traverses based on the theodolite traverse framework, with barometer heights based on the topographical levels forming the vertical framework, the surveyor taking every opportunity where the country temporarily opens out to any appreciable extent to substitute plane-table survey for compass traverses.

(b) *In the Open Triangulated Country.*—A plane-table survey based on the trigonometrical points. The telescopic alidade, "Close-Brooker" pattern, is used, thus securing great accuracy in both horizontal and vertical work. Where unusual difficulties such as patches of forest exist, compass or plane-table traverses are temporarily utilised in conjunction with barometer heights, the survey being based on the neighbouring triangulation or plane-table survey.

Distribution of Work and Responsibility of Surveyors.

10. With regard to the execution of the work, the guiding principle of the survey, whatever system is used, is that *each surveyor is given a definite area to survey*, and is entirely responsible for the completion in the field and the accuracy of the map covering that area. This method of distributing the work possesses such obvious advantages that it is almost superfluous to enumerate them. They are as follows:—

(a) Each surveyor knows exactly what work he has to do in a given period.

(b) Every surveyor gets the chance of proving, by the rapidity and fidelity of his work, his claim for personal advancement. *However, every man must bear in mind that the credit of the Department, and therefore the efficiency of the public service, is the first consideration.*

(c) Errors due to office compilation are eliminated.

(d) The production of the standard map sheet by sheet is accelerated.

(e) Subsequent work is rendered more efficient by giving any revision or supplementary surveys in a district to the surveyor originally responsible for the map of that area.

Field Season and Recess, Topographical Branch.

11. The rainy season varies considerably in the three provinces, and also in successive years, but work in the field is generally entirely impracticable between June and September, besides being very unhealthy in May owing to the rains, and difficult in October owing to swollen rivers.

The Field Season extends from about 1st October to 31st May. During the first ten days a surveyor is employed in transporting his stores to his field area, preparing his field sheet in the Headquarter Office, collecting information, and generally organising his party. During the last ten days he is employed in putting the finishing touches to his field sheets in the Headquarter Office, tabulating the results of his work, writing his report, and cleaning and storing his equipment.

The Recess is spent in the voyage to and from England, and in leave in England, though the surveyor is called on to do a large amount of work both there and on the voyage.

Embarkation.—The Topographical Branch embarks by the first boat leaving Lagos on or after 1st June, and returns by the first boat leaving Liverpool on or after 15th September.

During either the first or last months of the recess the native surveyors of the Topographical Branch are granted one to two months' leave, after or before which a certain number are attached to the Cadastral Branch, others as temporary instructors to the School, and the remainder employed on special topographical surveys.

Leave of Cadastral Branch.

12. Owing to the fact that work in the towns is generally possible in the rainy season, the Cadastral Branch takes the usual leave authorised by the Colonial Service Regulations, viz., one year on the Coast and about five months away.

General Organisation, Southern Nigeria Survey.

13. (a) Owing to the very different nature of topographical and cadastral work, the limited season suitable for field topographical work, and the necessity for maintaining the continual supply of cadastral plans and information required by the Lands Department, the Southern Nigeria Survey is organised into—

1. Headquarter Office.
2. Topographical Branch.
3. Cadastral Branch.
4. School and Meteorological Branch.

(b) The Southern Nigeria Survey is governed by the *Survey Handbook* and *Survey Circulars* which are described in paras. 45 and 46.

Headquarter Office.

14. *The Headquarter Office* is for the general administration of the Southern Nigeria Survey. It includes the survey stores, and carpenter's and photo shops. The staff consists of a European officer in charge of Headquarter Office (the Chief Assistant), one chief clerk, one third-class clerk, one second-class clerk (finance clerk), one third-class clerk (storekeeper), two assistant photographers, one chief headman, one carpenter and three assistants, and one bricklayer and assistant. Messengers and copyists are also employed according to the pressure of the work.

Topographical Branch.

15. (a) *The Topographical Branch* consists of—

1. The Topographical Office.
2. The Trigonometrical Section.
3. The Topographical Section.

(b) The Topographical Branch is under the direct control of the Director of Surveys, assisted by the Deputy Director of Surveys, Topographical Branch (D.D.S.T.B); the Assistant Director, Trigonometrical Section (A.D.T.S.); and two or more Assistant Directors, Topographical Branch (A.D.T.B.).

(c) In the absence of the Director, the Topographical Branch is under the direct control of the Deputy Director of Surveys, Topographical Branch, who is responsible to the Acting Director for the efficiency of his branch.

Topographical Office.

16. *The Topographical Office* is under the charge of the Chief Native Draftsman, but works under the general supervision of the Chief Assistant, Headquarter Office. The subordinate staff consists of two to three draftsmen, and of a varying number of probationer draftsmen.

The duties of the Topographical Office consist of: preparation of field sheets; compilation of special maps and of survey work coming from sources outside the department; the registration of field books, drawings, etc.; and the execution of any drawings required by the Topographical Branch. Also the preparation of any maps specially required for military or other services.

Trigonometrical Section.

17. *The Trigonometrical Section* is charged with the main and minor triangulation of Southern Nigeria, and consists of one or more trigonometrical camps working under the Assistant Director, Trigonometrical Section (abbreviation—A.D.T.S.). The Assistant Director, Trigonometrical Section, is responsible to the officer in charge of the Topographical Branch for the efficiency of his section, the fidelity of its work, and the training therein of native subordinates.

18. *The Topographical Section* is charged with the topographical survey (except main and minor triangulation) of Southern Nigeria. It works under the direct control of the Director, and is divided into Field Camps, each consisting of one to two European surveyors (the senior of whom is called the Camp Officer), and from one to four native surveyors, with probationers, headmen, chainmen, and carriers. The field camps work in "groups," each group working under the group officer, who is usually an Assistant Director, Topographical Branch. Each field camp is allotted a certain definite area to survey, and the camp officer is entirely responsible to the Director through his Assistant Director, Topographical Branch, for the efficiency of his camp and the completeness and accuracy of his map.

Topographical Section and Field Camps.

Details of the organisation of Field Camps are given in Chapter II.

19. *The Cadastral Branch* is under the charge of the Deputy Director of Surveys, who is responsible to the Director for the efficiency of the branch and the quality and quantity of the work produced. The Cadastral Branch is divided into: (I.) *A Cadastral Office* for the conduct of correspondence on technical subjects; Staff—one third-class clerk. (II.) *A Cadastral Drafting Office* for the preparation of plans; Staff—three to four draftsmen, and two to three probationers. (III.) *Cadastral Parties* for the execution of town, property, and concession surveys.

Cadastral Branch.

Regulations for the organisation and conduct of Cadastral Surveys are given in Part II.

20. *The Survey School* is under the charge of the Chief Instructor, who is responsible to the Director for the efficiency of his staff, the state of the school buildings and observatory, the training of the pupils, and the conduct of meteorological work. His staff during the recess consists of two native surveyors of the Topographical Branch.

Survey School.

Pupils at present are trained for future employment as follows:—

As topographical surveyors . . .	80 per cent.
As cadastral surveyors	20 „

Any deviation from the above scale must be sanctioned by the Director.

A certain number of pupils are accepted for instruction in drawing only.

For the field season, the topographical pupils (except the junior class) are attached to the Field Camps, and the cadastral pupils to the Cadastral Branch, all after the first year's school.

The leave of the Chief Instructor is taken during the field recess.

21. The chain of responsibility indicated in the preceding paragraphs is to be strictly adhered to, and no officer is to short-circuit the system by giving an order to any person in any other branch, field camp, cadastral party or school, without reference to the officers in charge of those units, except under very exceptional circumstances, in which case the officer giving the order will be held responsible.

Chain of Responsibility.

On the same principle no survey officer is responsible to any officer outside the Department, nor is he on any account whatever to carry out *any order concerning his work* given him by such an officer without reference to the Director. If he receives any order *not in any way concerning his work* from a superior officer in any Government department he will carry out that order, but at once inform the Director.

The officers of the Southern Nigeria Survey will, however, it is trusted, not forget that one of the principles which should guide the Department is to exhibit every courtesy, and to lend all reasonable help possible, to the other public departments of the colony. They will, of course, be guided by the Colonial Service Regulations, and are to pay particular attention to the wishes of a Commissioner concerning the treatment of natives, etc., while working in his district. Officers will often find that they can give some small help to local Government officials, such as executing a small survey for them or giving them a tracing of part of their map, and they should always do so if not detrimental to their work.

Warning to Surveyors on Promotion.

22. All survey officials are warned that should they, on promotion to a higher grade, slacken their energies and diminish their out-turn, their grade will be promptly reduced. Annual increments will not be recommended unless the surveyor's work is entirely satisfactory.

Prevention of Oppression of Villagers.

23. Officers must do all in their power to prevent any oppression of the villagers by their staff; they will report at once to Headquarters any circumstance of this nature coming under their notice.

Gratuitous labour is in no case to be demanded from the natives. If they are considerately dealt with they will usually be found willing to lend reasonable assistance whenever necessary.

Subordinates are granted tents, travelling allowance, and a certain amount of camp equipment. They are therefore prohibited from demanding accommodation in houses in the area under survey.

Presents, Gratuities, and Payments.

24. Any member of the Southern Nigeria Survey who can be proved to have received, on any pretence whatsoever, any present or gratuity from his subordinates or from the inhabitants of districts in which he may have been or is employed, will be summarily dismissed.

Officers should pay, and insist on their subordinates paying, for every article supplied to them at the recognised rates. Should it be found that there is cause for complaint, a representation will be made by the officer in charge to the District Commissioner.

In certain districts water and firewood can be obtained gratis, but this cannot be enforced, and must be looked upon as an act of courtesy and hospitality.

No member of the Southern Nigeria Survey is allowed to do any outside work either for or without payment, or to publish any book or document, without first obtaining the permission of the Director.

25. Officers and subordinates of the Department indulging in sport are warned :—

Trespassing and Sporting Prohibitions.

(1) Against trespassing on standing crops without the consent of the owners.

(2) Against shooting birds or animals, which are looked upon as sacred in the vicinity of villages or habitations.

(3) Against shooting domestic animals, such as dogs or pigs.

(4) Generally against shooting or fishing in the immediate neighbourhood of villages, temples, or mosques.—(From S.I.)

26. (a) Headmen, chainmen, and carriers are not to travel by rail unless under very exceptional circumstances, which must be at once fully reported to Headquarters.

Regulations *re* Use of Railway.

(b) At the beginning and end of the field season the whole gang of each field camp will be sent by road, carrying full loads, and thus reducing railway expenses. Loads that are left over will be taken by rail by the surveyor.

(c) Surveyors and chief native surveyors are allowed to take one boy and one cook each by rail, and other native surveyors one boy each.

(d) All surveyors are allowed to take one bicycle each by rail.

(e) A list of camp officers who are permitted to sign railway warrants will be published periodically in a survey circular, a copy of which will be forwarded to the Traffic Superintendent, Lagos Government Railway. All officers to whom such permission is given will exercise every reasonable economy in the use of the warrant.

(f) Telegrams sent by the Lagos Government Railway Telegraph must be paid for.

27. (a) By the courtesy of the General Manager, field camps and other survey parties are permitted to form field depôts at the nearest convenient railway station. Camp officers should remember that this is an act of courtesy which causes additional work to certain railway officials, and should be careful not to abuse it.

Railway Field Depots.

(b) A list of the field depôts and the parties using them, giving the names of the surveyors, will be published from time to time in survey circulars, and a copy sent to the Traffic Superintendent.

(c) When a camp officer leaves his stores with the stationmaster who is looking after his field depôt, he will give him a complete list and obtain a receipt from him. As more than one field camp may have its depôt at one station, the list must be headed by the number of the field camp.

(d) When a camp officer sends to the field depôt for stores, he must write his demand clearly and head it with the number of his field camp. The demand should be signed as a receipt, and the messenger instructed to leave it with the stationmaster.

(e) A surveyor's mails and all extra stores required by him during the field season will be sent from Headquarters to the field depôt of his camp. Mails and stores must be clearly addressed with the name of the surveyor and the number of his field camp, and booked to the care of the stationmaster.

(f) The use of field depôts for inter-communication is given in para. 88.

(g) A field depôt will not be altered without the Director's sanction.

Other Field Depots.

28. (a) When working out of reach of the railway, field depôts may be formed at any buildings under the charge of the Southern Nigeria Marine, the Postal, Telegraph, Police, and Medical Departments, and the West African Field Force, the officers in charge having kindly given their permission for such procedure.

(b) The remarks and instructions in para. 27 apply to these field depôts.

(c) In the case of field camps working in remote regions where the only Government post is a military station, the officer commanding troops kindly allows camp officers to build a temporary hut for their spare stores next to the guard-room, and to place it under the charge of the guard through the local commanding officer.

Unfaithful Work.

29. (a) All survey officials who, after having been sufficiently trained, submit field work that requires to be revised render themselves liable to forfeiture of travelling allowance, to deferment of increment, to forfeiture of increment already granted, or to any other punishment that the Governor may impose.

(b) Any survey official who submits documents, maps, plans, or records containing intentional errors renders himself liable to prosecution and instant dismissal.

(c) *The checking of all work, whether field work or office work, is a most important duty*, and all officials of the Survey must remember that their signatures on a plan, co-ordinate sheet, or other document testify to the accuracy of that document, whether signed as originator or checker.

(d) Officials guilty of repeated acts of carelessness in the discharge of their duties render themselves liable to the penalties mentioned in (a).

Correspondence and Diaries.

30. (a) All correspondence between the various branches of the Department and the Headquarter Office will be conducted in memorandum form either in pencil or ink, but in requisition for stores ink must be used.

(b) All letters to be addressed to the Director of Surveys by the title only.

(c) The Chief Clerk will open all letters except those marked "Confidential," "Personal," or "Secret," and will have them ready for the Director's perusal, together with any reference file, by the office hour daily.

(d) Surveyors must mark in red "Secret," and seal, all envelopes containing information concerning foreign Powers. The envelope to be enclosed in another envelope, also sealed, both to be fully addressed. If sent by post, to be registered.

(e) Confidential communications will be marked "Confidential," and further treated as in (d).

(f) Secret and confidential letters will be opened by the Director only, or, in his absence in Headquarter Camp or from the colony, by the officer left in charge at Headquarters.

(g) All letters marked "Personal" are not to be opened by any other person but the Director.

(h) Surveyors must be careful to frank all letters sent by post with name and department in left-hand bottom corner, official letters only to be so treated.

(i) The officer in charge of each office will keep an official diary recording the day's work. The Headquarters diary will be kept by the Chief Assistant, or, in his absence, the Chief Clerk, and inspected periodically by the Director. The arrival and departure of surveyors at Headquarters will be entered.

The Topographical and Cadastral Office and School diaries will include either in themselves or on separate form a record of the day's work.

All surveyors and native surveyors will keep a diary in which they will record the day's work, weather, and other useful information. *The careful upkeep of these diaries is essential for the compilation of the Annual Report.*

All diaries to be sent to the Headquarter Office at the end of the field season by both branches.

(j) All correspondence with other Government offices will be conducted by the Headquarter Office, except that on technical subjects between the Cadastral Office and the Commissioner of Lands.

Acting Duties.

31. (a) During the Director's absence from the colony on leave the Deputy Director will be Acting Director, while continuing his duties in the Cadastral Branch.

(b) During the field season, when the Director is absent from Headquarters, the Chief Assistant will carry on the routine work of the Headquarter Office in order to avoid disturbing the Deputy Director in his duties of administering the Cadastral Branch. The Chief Assistant, will, however, bear in mind that the Deputy Director of Surveys is in charge of Headquarters during the Director of Surveys absence, and will refer all matters affecting the welfare of the Department to him. The Deputy Director of Surveys will use his discretion in dealing with the matters in question, either forwarding them to the Director of Surveys, retaining them (if not urgent) until his return, or dealing with them himself.

(c) When the Director is absent from Lagos the Deputy Director of Surveys will arrange to visit the Headquarter Office daily to deal with papers. It is strictly ordered that no correspondence except that connected with the Cadastral Branch should be sent to, or left in, the Cadastral office.

Remarks on Supplementary and Revision Surveys.

32. (a) A supplementary survey is a topographical survey executed to bring existing maps up to date, and is also resorted to where cadastral surveys exist and are of sufficient value to be utilised in the compilation of topographical maps. "The details from these surveys are reduced, transferred to the plane-table sheets in blue, and checked in the field by the plane-tablers, and all detail omitted

in the cadastral maps, such as hills, ravines, etc., is 'supplemented' by actual surveys" (S.I.).

(b) "It is frequently not an easy matter to decide when a 'supplementary survey' will suffice, and when a re-survey is necessary. The process of reducing and transferring the details from a cadastral map to the plane-table sheet is always a laborious undertaking, so that a 'supplementary survey' may at times cost more than a re-survey, especially when few topographical items have been shown on the cadastral maps. Again, surveyors, to save themselves trouble, are apt to accept too much of this detail as correct without examining it thoroughly on the ground, and very close and constant supervision by officers in charge of camps is indispensable."—(S.I.).

(c) It may generally be accepted that all cadastral surveys of concessions executed in Southern Nigeria prior to June 1910 require "supplementary survey" in a greater or less degree to make them of any topographical value. "Items of topographical importance and other general utility are generally overlooked by cadastral surveyors, who are not usually trained to delineate these features, their chief attention being directed to fiscal details, so that a standard map compiled solely from revenue survey material without 'supplementary survey' must always be treated as a 'preliminary edition,' and published as such" (S.I.).

(d) In order to obviate the necessity of "supplementary surveys" of concessions, the Cadastral Branch will in future either execute the complete topographical, as well as cadastral, survey of concessions, or will have attached to it a surveyor of the Topographical Branch for that purpose.

(e) Supplementary surveys to bring existing maps up to date are usually called *revision surveys*. "In a revision survey a copy of the original field sheet is mounted on a plane table, and new public works, such as roads, railways, tanks, canals, and changes of river beds, village names, and sites, are inserted or corrected thereon by surveyors in the field. This information is in the first instance obtained from the Marine and Public Works Departments, District Commissioners, Intelligence Officers, etc., who are supplied with printed copies of such maps, and asked to indicate roughly therein all changes, errors and omissions they may be aware of" (S.I.).

Scale of Survey.

33. (a) Various considerations influence the choice of the scale most suitable for the survey of any particular district or area, such as the nature of the country itself, military and other requirements, and the time available for its completion. No survey should be undertaken until these points have been thoroughly considered in consultation with the military and local authorities.

(b) The scale of the standard map of Southern Nigeria is 1:125,000, but the scale of survey is usually 1:62,500, and is frequently larger. In hilly or open country, where the population is sparse and roads and artificial features are few and far between, the 1:62,500 scale is generally quite large enough, and the expense entailed by working on a larger scale would rarely be justified. In exceptional cases, as in well-cultivated and open ground and

in country where there is a large amount of detail, especially where revenue or cadastral surveys have been carried out, the scale of 1 : 31,250 is generally preferable, as it gives greater detail and enables all village boundaries to be shown, which, in consequence of the small area of some villages, cannot be done on the 1 : 62,500 scale.

(c) A 1 : 62,500 or 1 : 31,250 survey is much easier to examine and check in the field than a survey on the standard scale, especially in intricate country where there is much detail, and it will generally be found in practice that one can survey almost as fast on the former as on the latter scale.

(d) Special military surveys are sometimes required of limited areas for such purposes as the manœuvring of troops. Generally a good scale for this purpose is 1 : 31,250, while a survey on the 1 : 12,500 scale is occasionally needed for defensive and other positions.

With general acknowledgments to S.I.—

(e) The following scales will be used in the Southern Nigeria Survey :—

For Topographical Surveys—

Standard Map . .	1 : 125,000 (1·014″ = 2 miles).
Standard Field Sheets .	1 : 62,500 (1·014″ = 1 mile).
Auxiliary Field Sheets .	1 : 31,250 (1·014″ = $\frac{1}{2}$ mile).
	1 : 25,000 (1·014″ = $\frac{2}{5}$ mile or 704 yds.).
	1 : 12,500 (1·014″ = $\frac{1}{5}$ mile or 352 yds.).
Charts of Framework, Triangulation, etc. .	1 : 125,000 and 1 : 500,000 (1·014″ = 8 miles).

(f) *For Cadastral Surveys—*

Lands of less than $\frac{1}{4}$ square mile in area on any of the following :	1 : 50, 1 : 100, 1 : 500, 1 : 1000, 1 : 1250, 1 : 2500.
Of $\frac{1}{4}$ square mile but less than 5 square miles,	1 : 6,250.
Of 5 „ „ 25 „	1 : 12,500.
Of 25 „ „ 100 „	1 : 25,000.
Of 100 „ „ 200 „	1 : 31,250.
Of 200 square miles and greater,	1 : 62,500.

(g) In reference to the scales authorised above for cadastral surveys, exceptions occur in the case of those surveys of concessions, reserves, towns, etc., completed or completing in June 1910, and of any supplementary cadastral surveys connected therewith.

(h) Three scales will be drawn on all topographical maps, showing respectively miles, feet, and metres.

(i) Two scales will be drawn on all cadastral plans, showing respectively feet and chains.

(j) Remarks on scales suitable for auxiliary sheets are given in para. 64.

34. (a) A first-class headman receives from 2s. to 2s. 6d. per diem, according to his abilities. He must be able to speak, read, and write English fairly, to control his gang, to chain, make fair sketches with compass and protractor, range lines, and book times. If he discharges the above duties to the satisfaction of his camp officer, has

been well behaved, and kept his men under efficient control, he will be granted one month's leave on half-pay during the recess, and employment will be found for him while waiting for the beginning of the next field season if possible.

Headmen, Chainmen, and Carriers.

(b) A second-class headman receives from 1s. 3d. to 1s. 9d. per diem. He must be able to speak English intelligibly, to chain, range lines, and control his gang.

(c) At the beginning of the field season the rates of pay of headmen employed by the field camps are laid down by survey circular. Should a headman prove unsatisfactory, the camp officer should at once cut down his pay or discharge him, reporting the circumstance at once to Headquarters. On the other hand, recommendations for promotion should be freely made. The promotion of a chainman to a second-class headman has excellent effects, especially if done publicly and with a certain amount of ceremony before the assembled gangs.

(d) Chainmen receive from 1s. 1d. to 1s. 3d. a day, according to ability. They are merely men selected and trained to manipulate the steel band, and do not do the actual reading, etc., as all measurements are made by the surveyor himself. They only receive 1s. a day when not actually employed on chaining. On these days they must be employed in clearing lines, carrying loads, etc. It is a common fault to keep chainmen idle when there is no chaining to do.

(e) At the end of the field season all headmen and chainmen whom it is desirable to re-employ again after the recess will be given a re-engagement paper by the surveyor under whom they have worked, signed by the surveyor and countersigned by the Director of Surveys. The Chief Assistant, Headquarter Office, will keep a list of these men. *See* (g).

(f) Chainmen and carriers will receive no pay for non-working days, or for days when they are sick through their own fault. Any man developing gonorrhea or a similar complaint will be at once discharged. A man who is genuinely sick will receive full pay for a week. A man injured during work will, provided that the accident did not occur through his own fault, receive pay for a reasonable length of time.

(g) *Re-engagement Paper, No....., Field Camp:—*

1. Name.....
2. Employment..... ....
3. Rate of Pay.....
4. Control of Gang.
5. Compass Sketching.
6. Chaining.
7. Ranging.
8. Speaks English?
9. General Character.
10. Is he recommended for Re-engagement?
11. Has he been definitely Re-engaged?
12. Date and Place for Rejoining.

(h) When any unit leaves Headquarters for work in the field, and takes with it any men who are already working in the Department,

these men will be paid up to the day before leaving by the officer in whose branch they have been employed.

(i) On the day of leaving Headquarters, or of the formation of the unit, all the men come on the Camp Officer's Carriers' Book, para. 39 (g).

(j) On the breaking up of the unit all men will be paid up to date and the book closed. Any men whom it is thought desirable to retain, and for whom there are vacancies, will be transferred to the books of their new units.

(k) It is a camp officer's duty to see that subpara. (h) is complied with. It is also his duty, when he dismisses a man, to pay him up to date. Should it be absolutely necessary to send a man to Headquarters to be paid off, he must send the Chief Clerk a paper containing the abstract shown in para. 39 (g). The amount shown under "Settlement" in the abstract is paid to the man at Headquarters, shown as an advance against the camp officer in the Director's Ledger, and the camp officer duly informed. The camp officer enters the amount both on the receipt and expenditure sides of his cash account, and also enters the amount in the "final settlement" column of his Carriers' Book, and *furnishes the full voucher;* thus acting as if he had paid the man himself. The camp officer must not do this until he has received a notification from Headquarters that the man has been paid off.

(l) Camp officers are to do all in their power to avoid sending carriers to Headquarters to be paid off. It is recognised, however, that the course may occasionally be necessary.

Reporting to Commissioners, Public Functions, Arrivals and Departures.

35. (a) All officers, European and Native, are to report their arrival in a district in writing to the Commissioner, and if their duties carry them to his Headquarters they will report personally. While working in his district they will keep him generally posted as to their whereabouts.

(b) On landing after absence from the colony all officers will, after reporting their arrival at Survey Headquarters, report personally to the Colonial Secretary.

(c) All European officers, the Chief Instructor, the Chief Clerk, the Chief Native Surveyor, and the Chief Native Draftsman will, if in Lagos, attend such public functions as the arrival or departure or swearing in of the Governor, unless exempted by the Director.

(d) On the departure of the Director on tour, the Deputy Director and the Chief Assistant, Headquarter Office, will ascertain from him the hour at which they will report to him to receive any final instructions that may be necessary.

(e) It is the duty of the Chief Assistant, Headquarter Office, to make all arrangements for the arrival and departure of the staff, whether by steamer or rail.

Annual Reports.

36. To enable the Director to furnish the Annual Reports of the Southern Nigeria Survey to the Government and the Colonial Survey Committee, the Officer in charge Cadastral Branch, the Chief Instructor, and Group Officers will send in reports to Headquarters respectively on the Cadastral Branch, School, and Field Camps by the 31st May yearly. The officers

mentioned will take every care to collect such information during the year that will make their reports of real value in recording not only the output, but in advancing the future work of the Department. In these reports suggestions tending to economy and efficiency are always welcome, and should be made freely in appendix form.

Annual Estimates.

37. The Officer in charge of the Cadastral Branch and the Chief Instructor, Survey School, will submit their estimated expenditure and revenue for the next financial year to Headquarters by 15th April yearly.

Supply of Money: Monthly Remittances.

38. (a) Camp officers draw a supply of money monthly from the nearest treasury. Such sums are hereafter referred to as "monthly remittances."

(b) Camp officers must keep a careful cash account to account for their disposal of monthly remittances. These accounts are dealt with in para. 39.

(c) The system is as follows. The Director applies for an imprest for the total amount required by the field camps to a certain date, pays this imprest into his official banking account, and sends monthly remittances by cheque to the various camp officers. Cheques are crossed "B. of B.W.A., Ltd., Account of Colonial Government."

(d) A list of the camp officers, the amount of their remittances, the names of the treasuries where the cheques will be presented, and the probable dates of presentation, is published in a survey circular, and a copy sent to the Financial Commissioner, Lagos, to enable him to warn his treasurers.

(e) On the date on which the cheque is made payable becoming due, the camp officer sends his cheque by a special messenger to his treasury, with a request for the despatch of the money to him at a named place under escort. The camp officer should be careful to allow sufficient time for the messenger's journey and return, and should inform the local treasurer of the date he will be at the place named. If the exigencies of the service prevent the camp officer being at this place to receive the money, he should send a reliable man to guide the escort to his camp.

(f) Camp officers in the Lagos district will have their monthly remittances sent in cash under escort direct from the Headquarter Office. These remittances will not be sent until a letter is received at Headquarters notifying the place and date where the camp officer wishes the money sent.

(g) Camp officers will arrange with the Director at the beginning of the season the amount of their respective monthly remittances. Should any special need for an extra supply of money arise, a camp officer must apply for an "extra remittance" to the Director, bearing in mind that some delay may occur before he can draw the money.

(h) When a field camp forms part of a group, all monthly remittances will be made by cash or cheque from the Director to the group officer, who is responsible for the delivery of the money to the various camp officers.

(i) When a camp officer wants a remittance from a group officer, he will send a policeman with the weekly messenger, para. 88 (b).

39. (a) Salaries and allowances will be drawn in the usual way. Vouchers for all salaried officers will be made out monthly at the Headquarter Office and forwarded for signatures to the camp officer, who will return them at once to Headquarters. If the voucher is for the pay, etc., of an assistant who has not got a private banking account, the camp officer will regard the voucher as one between himself and the Director. He will give it his own number as in subpara. (k), and enter it in his voucher record as in subpara. (n).

Salaries and Disposal of Monthly Remittances.

If the voucher is for the *allowances* of himself or an assistant with a banking account, the voucher is simply signed and returned to Headquarters, a record of its despatch being furnished by the carbon copy in the Camp Officer's Letter Book.

Vouchers for *salaries* of all officers with banking accounts need only be signed by the Director, and are therefore not sent out to field camps.

(b) Camp officers who draw their salaries in England may pay themselves a sum not exceeding two-thirds of their salary for the month for current private expenses, such sum not to exceed £25, and will at once send a cheque for the amount to the Director, the cheque being made payable to the "Crown Agents for the Colonies" and crossed.

Camp officers who draw their salaries locally must arrange for them to be paid into a Lagos bank. In this case a camp officer will be allowed to pay himself two-thirds of his salary, as before mentioned, and his cheque must be made payable to the "Director of Surveys" and crossed.

The cheques mentioned in this subpara. are vouchers between the camp officer and the Director, and should be numbered as such.

(c) Camp officers will pay their assistants monthly.

In the case of European assistants the rules given in (b) will be observed.

In the case of native assistants, camp officers will pay them the whole of their month's salaries and allowances every month on their signing the vouchers mentioned in subpara. (a).

If a native assistant has an account with a Lagos bank, and has made arrangement for his monthly salary and allowances to be drawn by that bank from the treasury, the camp officer may pay him a monthly sum not exceeding two-thirds of his salary and allowances for that month. The assistant will give the camp officer a cheque for the amount, made payable to the "Director of Surveys," and this cheque will be at once forwarded to the Director.

These cheques are vouchers between the camp officer and the Director, and should be numbered.

(d) A proportion of the salaries due to headmen and gangs will be paid by the camp officers at the end of every month, the proportion being arranged with the men at the beginning of the season. It is not to exceed half their pay.

(e) Canoe hire, ferries, guides' pay, and chiefs' fees will be paid out of the monthly remittances, but stores will not be purchased, except under very exceptional circumstances, without reference to the Director.

(f) Camp officers are not authorised to spend monthly remittances on any other items than those mentioned in (b), (c), (d), and (e).

(g) *A Carriers' Book* will be kept in the approved form, showing the men's names, date of engagement and dismissal, and rate of pay. Several columns will be kept in which non-working days will be entered. Columns will be kept for fines, and columns (headed by the date) for payments. At the end of the book will be an abstract to facilitate final settlement, such abstract showing:—

Column I. Total number of days from engagement to dismissal.
„ II. Number of non-working days.
„ III. Number of working days (I.-II.).
„ IV. Total amount earned.
„ V. Total amount of fines.
„ VI. Total advances.
„ VII. Net amount due on settlement (IV.-V. and VI.).

These columns will be filled in whenever a man is paid off.

(h) A separate page will be kept in similar form for headmen and chainmen.

(i) Vouchers for skilled labourers and carriers will be prepared in the original by camp officers and furnished to the Director at the end of the season, any copies required being made by the Headquarter Office. A "fines" column will be made on the voucher so that the latter will show the total net payment to each man under Columns VI. and VII. of the abstract (g).

(j) Camp officers should remember that the only way by which they can account to the Director for the monthly remittances is by vouchers and the cheques mentioned in (b) and (c).

(k) All vouchers will be kept in a file and numbered consecutively in red ink in the left-hand bottom corner, the number in all cases being over the letters F.C. and the number of the field camp, as, for example, $\frac{1}{\text{F.C. } 7.}$ All vouchers will be handed in at the end of the season, with the exception of those mentioned in (a), which will be returned monthly, and those mentioned in the next subparagraph.

(l) The following vouchers will be sent so as to arrive at the Headquarter Office not later than the 17th December:—

Vouchers for December pay and allowances of camp officers and assistants; vouchers for any item under (e).

(m) *Field Camp Accounts.*—The camp officer will keep a cash book in which he will enter all monies received and spent. Opposite each item of expenditure he will enter in a separate column the number of the voucher in which that item is accounted for. When paying men there is no necessity to enter each man's name in the Cash Book. The entry "Carriers," followed by the total amount paid on that date, is sufficient, the amount corresponding to the total at the foot of the "Advance Column" for that date in the Carriers' Book. For example: the entry "30th Sept. Carriers. Pg. 13/I. £10," means that on page 13 a record of the sums paid is given in Column I.

(n) At the end of the Cash Book a list of the vouchers showing their numbers and amounts must be made, and the date of their

despatch to Headquarters noted in a separate column. The cheques sent by the camp officer mentioned in (b) and (c) appear as vouchers.

(o) A camp officer will be prepared to settle up accounts the day after return to Headquarters, by which time he should have completed his vouchers, Carriers' Book, Cash Book, etc., in correct form.

(p) Camp officers must keep their books up to date, and are held responsible that books, vouchers, files, etc., are ready for inspection at any moment.

40. Working Hours, Southern Nigeria Survey. The following are the working hours of the Department :—

I. *Headquarter Office.*

7.30 to 11.30. 1 to 4. Clerks and photo shop.

6.30 to 11. 1 to 4. Stores and carpenter's shop.

II. *Topographical Branch.*

(a) Drafting Office. 7.30 to 11.30. 1 to 4.

(b) Any Topographical Branch gangs in Lagos will parade at 6.30 A.M. and 1 P.M. with the cadastral gangs, as in III.

(c) For work in the field, *see* para. 87.

III. *Cadastral Branch.*

6.30 A.M. (a) First working parade in the cadastral compound under the Chief Assistant.

(b) Chainmen and carriers will fall in by gangs: the Chief Headman will ascertain that all are present, and will report to the Chief Assistant.

(c) Surveyors will attend this parade. Stores will be issued, and the parties proceed to the scene of survey in time to arrive there by 7 A.M.

(d) Any gangs not required for survey will make beacons and carry out general cleaning and transport work.

(e) Storekeepers will attend this parade to issue stores.

7 to 11. Work in the field.

11 to 1. Lunch recess.

1 to 4. Surveyors work in drafting office.

1 P.M. Gangs parade for general work until 4 P.M. under Chief Headman.

IV. *Cadastral Office and Drafting Office.*

7.30 to 11.30. 1 to 4.

V. On rainy days cadastral surveyors will conform to the order in subpara. IV., and gangs will parade at 7.30 A.M.

VI. *School and Meteorological Branch.*

7.30 to 11.30. 1 to 4.

VII. On Saturdays all work in Lagos will be continued until 12.

41. (a) All vouchers for pay and allowances will be prepared by the Finance Clerk under the supervision of the Chief Assistant, except those under Class E, and will be treated as follows :—

Vouchers.

Class A.—Allowances of all officers with banking accounts. To be prepared and despatched by the 7th of every month for the current month to the officers for signature and return. The vouchers will then be sent to the treasury for payment into the officer's

banking account. The salary and duty pay vouchers of all officers with banking accounts need not be sent out for their signatures.

Class B.—The salaries and allowances of all officers and pupils in Lagos without banking accounts. Prepared by the 7th of the month for the current month and despatched for signature and return. The cheque for the amount will be obtained from the Director by the Chief Assistant, who will make payments on the last day of the month. In the absence of the Chief Assistant, payments will be made by a European officer detailed by the Deputy Director of Surveys.

Class C.—The salaries and allowances of all field camp officers and pupils without banking accounts. These will be prepared by the 7th of every month for the current month and despatched for signature and return. The cheque will be drawn from the treasury in favour of the Director, and paid into the Director's official account. The assistants are actually paid by the camp officers out of the monthly remittances, and the vouchers act as field camp vouchers.

Class D.—Vouchers for the payment of all Cadastral Branch skilled labour and carriers will be kept entirely separate from the Topographical Branch, and act as the Deputy Director's vouchers in settling his advances from the Director. They will be prepared weekly, in time for the Chief Assistant to draw the cheque from the Deputy Director of Surveys and make the payments at 4 P.M. every Wednesday for the preceding week.

Class E.—Vouchers for skilled labour and carriers of the Topographical Branch field camps will be prepared by camp officers, and copies made by the Finance Clerk. The vouchers will be ready on the day of returning to Headquarters. The amount required for settlement will be drawn by the camp officer from the Director and paid to the men, the voucher acting as a field camp voucher.

Class F.—(a) Vouchers for the skilled labour and carriers of the Topographical Branch not attached to field camps will be prepared weekly, and payment made by the Chief Assistant, as in Class D. They act as the Deputy Director of Surveys' vouchers.

(b) All cheques at Lagos must be cashed, and payments made by the Chief Assistant personally, or, in his absence, by a European detailed by the survey officer in charge at Lagos.

(c) The Finance Clerk will keep a file for each field camp of the vouchers received from the camp officer.

(d) The Finance Clerk will keep a voucher book showing at a glance the disposal of vouchers of each field camp in the following form :—

No.....FIELD CAMP.

Column	I.	Field camp's number.
„	II.	Office number.
„	III.	Item.
„	IV.	Amount.
„	V.	Date of receipt.
„	VI.	Date sent to treasury.
„	VII.	Date paid into bank.
„	VIII.	Remarks.

(e) Periodically the field camp vouchers will be sent to the treasury ; the Director will draw the cheque for them and pay it into his banking account. These field camp vouchers include the personal emoluments and allowances of all members of the staff who have no banking account.

(f) The personal emolument and allowance vouchers of all members of the staff who have an account at the Lagos Bank will not be entered in this voucher book, but will be sent direct to the treasury who pay the amounts into the surveyor's account direct.

(g) When field camp vouchers are passed by the treasury, as in (e), the cheque requisition is signed and forwarded to the treasury. When the cheque is received, the entries in the Director's Ledger Account will be checked by the Chief Assistant with the Finance Clerk's Field Camp Voucher Book.

(h) *Vote Service Ledger.*—All vouchers, whether field camp or general, will be entered in the Vote Service Ledger as soon as received in pencil and inked in when passed.

Travelling Allowances.

42. (a) All officers draw travelling allowance for each night absent from Headquarters according to the scale and rules laid down, always provided that the Director considers their work to be satisfactory.

(b) Pupils employed in field camps will be granted travelling allowance if in the opinion of the Director they are discharging their duties in a thoroughly satisfactory manner. Camp officers should recommend such pupils to the Director, but are in no case to do so unless the pupil is thoroughly competent to carry out all the survey work entrusted to him, and knows how to keep up the Cash and Carriers' Book and to deal with vouchers in the authorised manner.

Guides.

43. The attention of camp officers is drawn to the necessity of employing guides occasionally. Those guides should be obtained from the local bale or village headman.

If employed for a whole day a guide should be paid 2s. Should the journey take the guide a day's march from his home, he should be paid 2s. for his return journey.

The above are maximum rates.

The name of the guide must be entered in the Account Book, and the payment of his fee witnessed by the assistant or camp headman.

When employed in the slow work of traversing, it would naturally be extravagant to employ a guide for the whole day. On these occasions information should be obtained from farm people, villagers, etc., or a guide be hired for a month at from 25s. to 30s.

Survey Records.

44. It is the duty of the chief draftsmen of the Topographical and Cadastral Branches to file and record the work of their respective branches.

Topographical Record Books.—The following records will be kept in the Topographical Office, under the supervision of the Chief Assistant :—

I. Framework Record Book. This contains the following details :—
   (a) List of theodolite traverses.
   (b) List of topographical levels.
   (c) List of observed and amplitude latitudes.
   (d) List of observed and amplitude longitudes.
   (e) List of accepted latitudes and longitudes.
   (f) List of preserved azimuths.
II. Field Book Catalogue.
III. Beacon Record Book.
IV. Map and Plan Catalogue.
V. Record of Heights. (This is a file of those survey circulars containing the lists of accepted heights.)
VI. Map Index.

All these books contain references by which the field books, plans, co-ordinate sheets, calculations, etc., can be promptly obtained.

Cadastral Record Books.—Similar books will be kept in the Cadastral Office, except that the Framework Book will contain a record of all town surveys and other work executed by the Cadastral Branch.

Records.—The following records will be kept neatly and methodically docketted in each office :—

I. Field books.
II. Co-ordinate sheets.
III. Maps and plans.
IV. Astronomical angle books.
V. Astronomical computations.
VI. Trigonometrical angle books.
VII. Trigonometrical computations.
VIII. Amplitude computations.
IX. Notes on the compilation, construction, and adjustment of maps and plans.

Receipt of Records.—On receiving field books, plans and other records, the Chief Assistant will at once number them where necessary, enter them and the necessary details in the proper record book, and put them in their proper shelf or drawer.

Levels.—On receipt of levelling books the Chief Assistant will make an extract from them of those natural and artificial objects of which the heights have been fixed and hand them to the Chief Clerk for issue as a survey circular.

The Chief Assistant will check the survey circular so issued with the original levelling books.

Azimuths.—On receipt of any records of azimuths that have been preserved by the erection of beacons, the Chief Assistant will hand a list to the Chief Clerk for publication as a survey circular in a similar manner as laid down for accepted heights.

Beacons.—The Chief Assistant will extract from the field books a list of all beacons and bench marks contained therein and enter them in the Beacon Record Book.

Checking Records Received.—Before putting away any of the records mentioned in para. 44, the Chief Assistant will see that the regulations as to their upkeep have been observed by the field camps. For example : That field books have the proper slips pasted in them, a list of contents, etc. ; that plans contain a heading, with point and

scale, etc.; that co-ordinate sheets are signed both by the computer and the checker, etc.

Any omissions, errors, or discrepancies to be at once brought to the notice of the Director.

Map Index.—The map index is to be kept up to date on the card index system as soon as the spelling of the names has been corrected by the Director. *See* para. 76 (b).

Survey Handbook.

45. (a) The *Handbook* of the Southern Nigeria Survey was issued in cyclostyle form in July 1910 with the object of standing the test of the first season's work before publication in the summer of 1911.

(b) The *Handbook* lays down the general organisation of the Survey, and gives full technical instructions, these superseding all previous instructions and method of work.

(c) The *Handbook* will be altered and added to from time to time, such alterations and additions being given in survey circulars. It is the duty of every officer who has a *Handbook* in his possession to make the necessary corrections without delay.

(d) It is the duty of every officer to know and understand every instruction contained in the *Handbook*. The duties of a surveyor are by no means solely confined to technicalities, but include a large amount of administrative work, on the efficiency of which depends largely the result of a field camp's season.

(e) The *Handbook* forms the basis of instruction in the Survey School.

Survey Circulars.

46. (a) The whole current work of the Department, such as instructions to field camps, arrivals and departures, promotions, etc., as well as additions and alterations to the *Handbook*, is effected by the periodical issue of survey circulars.

(b) Certain survey circulars are drafted automatically by the Chief Assistant. These chiefly notify arrivals and departures on every occasion when—

I. A surveyor embarks for, or lands from, England.

II. A surveyor leaves Lagos for, or returns from, the field.

(c) Survey circulars form the basis for calculating duty pay, allowances, etc.

(d) The Chief Clerk is responsible for the despatch of circulars to the following officers, whether they are personally concerned or not:—

I. One to each D.D.S., A.D.S., and camp officer.

II. Two to O.C.B.

III. One to C.I.S.

(e) A file of survey circulars will be kept by all the officers mentioned in (d).

(f) The file of circulars of every officer on leave will be kept up to date during his absence by the Chief Clerk.

(g) It is the duty of every officer to note the contents of survey circulars.

(h) Survey circulars signed by the Chief Assistant "for D.S." are to be accepted as if signed by the Director.

47. (a) Charts showing the organisation of the Department and the disposal of the various surveyors are to be kept up to date and hung in each office.

Organisation and Work Charts.

(b) Large black-boards in the Headquarter Office show the employment, etc., of every member of the staff. These "staff boards" are to be kept up to date, and every Monday the O.C.B., C.I.S., and chief draftsmen will send a member of their respective staffs to check the entries on the boards, and to note on their organisation charts any alterations on that hung in the Headquarter Office.

(c) Work charts showing the work to be undertaken, the date of commencement, etc., are to be kept up to date by every branch. Officers in charge are reminded that these charts form a record of the work of their respective branches.

(d) The Chief Assistant is responsible that this paragraph is carried out.

48. (a) One policeman is usually detailed to each field camp. Application for the services of the required number of police is made to the Commissioner of Police about a month before the beginning of the field season. On a policeman joining a camp officer, the latter should at once take from him his last pay certificate.

Police Escorts.

(b) Camp officers are particularly requested to keep their police up to the mark in smartness and cleanness, to inspect them in full marching order twice a week, and to watch them carefully lest they bully the villagers.

(c) The duty of the policeman is to guard the camp. He may be used as interpreter, etc., but not in any menial capacity.

(d) *Pay of Police.*—The Commissioner of Police pays monthly to the Director the total pay of all the police attached to the survey, and forwards him a voucher showing the amount to be paid to each man.

(e) The money is paid into the Director's bank account, and the Chief Assistant informs each camp officer of the amount he should pay his escort.

(f) The various amounts are credited to the camp officer in the Director's Ledger Account and checked with the camp officer's cash book at the end of the year.

(g) If a policeman does not wish to draw all his pay, the camp officer may keep the money for him, but he does this privately and at his own risk.

49. (a) All stores are under the charge of the Head Storekeeper, who is responsible to the Director through the Chief Assistant that all stores regulations are observed.

Stores Regulations at Headquarters.

(b) Stores will be kept under lock and key in the storerooms in the survey compound. Theodolites, levels, survey forms, field books, and drawing materials will be kept in No. 2 storeroom; general survey stores in No. 1 storeroom; and tents, hammocks, axes, and other heavy stores in No. 3 storeroom.

(c) i. *Drawing Offices and School.*—The Head Storekeeper will issue a certain amount of drawing materials, etc., to the chief

draftsmen of the Topographical and Cadastral Branches and to the C.I.S. in order to prevent numerous demands for small articles being presented daily. The C.I.S. and chief draftsmen will keep a list of the stores handed to them, showing their disposal.

ii. Each draftsman will be provided with instruments, etc., by the Head Storekeeper, but he will draw such expense stores as paper, pencils, etc., from his Chief Draftsman.

iii. In addition to the drafting stores mentioned in (ii), each office requires a certain number of stores for general use, such as arithmometers, eidographs, etc. The chief draftsmen will be responsible for these stores.

(d) *Surveyors, Cadastral Branch*, will draw their instruments, etc., direct from the Head Storekeeper, and field books, forms, etc., from the chief draftsmen.

(e) *Field Camps.*—Camp officers only will draw stores. No stores are to be issued to assistants by the Head Storekeeper unless their demand is signed by the Director of Surveys.

(f) *Loss of or Damage to Stores.*—All members of the staff are responsible for the care of the stores issued to them, and will be required to pay for loss or damage otherwise than by fair wear and tear. They are therefore cautioned to examine all stores issued to them before removing them, as complaints afterwards made cannot be considered. Any defects will be pointed out to the Head Storekeeper and notes made on Survey Form No. 6, and the counterfoil initialled by both the issuer and recipient.

(g) *Requisition for Stores.*—All stores will be requisitioned on Survey Form No. 6, which is bound in the form of a Requisition Book. The form will be handed to the Storekeeper and signed by the recipient of the stores. The counterfoil will always be filled in, and forms a record for the information of the recipient. *The usual issue voucher will be made out by the Storekeeper and signed by the recipient on the issue of the stores.*

(h) *Status of Storekeeper.*—The Head Storekeeper is responsible to the Director through the Chief Assistant for the custody of all stores, and members of the staff are required to treat him as the Director's representative. No instructions or reprimands in any form whatever are to be addressed to the Storekeeper. The Storekeeper will at once report any non-observance of this rule.

(i) *Care of Articles in Store.*—All articles in store will be kept in thorough working order, leather kept free from mildew, tapes greased, etc.

(j) *Ledgers, etc.*—The Head Storekeeper will keep up to date the following books, etc.:—

(i.) *Receipt and Issue Book.*—This is required by the Audit Department. All issues will be entered on the right-hand page, all receipts on the left-hand page.

(ii.) *Store Issue Voucher Case.*

(iii.) *Receipt Voucher Case.*

(iv.) *Invoice Case.*

(v.) *Local Purchase Order Case.*

(vi.) *Transfer Issue Voucher Case.*

(vii.) *Store Ledger.*—This will contain a record of articles on issue. One will be kept for, and a duplicate by, each field camp.

49A. The duties of the Chief Assistant are of a varied nature and chiefly consist of relieving the Director of the work of looking after numerous small but important matters of detail. Routine work forms the bulk of his duties, but the exigencies of service in tropical Africa will often lead to his being called on to discharge many duties that are not laid down for him.

Duties of Chief Assistant.

The Chief Assistant is on the personal staff of the Director, and is therefore under the orders of no one but the Director. As he ranks according to his salary in the European staff, he is in a somewhat ambiguous position, and the smooth working of the Department depends to an appreciable extent on the tact, zeal, and strength with which he discharges his duties. These are :—

I. *General Supervision of the Headquarter Office.* (*Vide* paras. 30, 31, 34 (e), 35, 46, 47.)

II. *General Supervision of the Topographical Office.* (*Vide* paras. 16 and 44.)

III. *In Charge of all Survey Stores.* (Para. 49.)

IV. Deals with all correspondence from field camps, extracting and complying with demands from stores, noting movements, and drawing Director's attention to reports.

V. Supervises the despatch of all mails, stores, etc., to field camps. Para. 27 (b) and (e).

VI. Supervises preparation of vouchers and finance work generally, and makes weekly payments. (Paras. 39, 41, 48.)

VII. Superintends working parades. (Para. 40.)

VIII. In charge of the carpenter's shop, construction of beacons, and photo shop.

IX. Makes weekly inspection of all survey buildings, as laid down in Survey Circular No. 15/1910. Survey buildings include any quarters occupied by the European staff. Reports on repairs, and additions necessary.

X. Makes all arrangements for the arrival, departure, and housing of the staff.

XI. Inspects monthly the Lagos base terminals, and sees that they are greased.

XII. Inspects annually the Eruwa base terminals, and sees that they are in good condition and cleared of bush.

XIII. The Chief Assistant will take his leave with the Topographical Branch, and during the recess is in charge of the Survey Office in England.

CHAPTER II.

FIELD CAMPS AND THEIR WORK.

50. THE composition of parties of the Topographical Branch employed in the field varies accordingly to the nature of the country in which they are working, and also according to the number of native surveyors employed in each. The detail given in (b) for a field camp is for forest country, where the carriers, in addition to shifting camp, are employed in clearing traverse lines. For open country, where plane-tabling is practicable, a field camp can be reduced by four to five carriers.

Strength of Topographical Parties.

The strength of a trigonometrical camp is considerably greater than that of a field camp, owing to the presence of four Europeans and the greater distances to be covered.

No increase in the numbers given is to be made without the sanction of the Director.

51. (a) *A Group Camp*—

1 Assistant Director, Topographical Branch (Group Officer).
1 Native Draftsman.
1 First-class Headman.
26 Carriers (including 3 chainmen).

Daily cost, excluding Group Officer and Draftsman, £1, 8s. 9d.

For details of loads *see* para. 52 (d) and Table II.

(b) *A Field Camp*—

1 Surveyor (Camp Officer).
1 First-class Headman.
19 Carriers (including 3 chainmen).
1 Second-class Headman. } Per additional European
12 Carriers (including 3 chainmen). } Surveyor.
1 Second-class Headman. } Per Native Surveyor.
5 Carriers. }

Daily cost, excluding Camp Officer and Surveyor, £1, 1s. 9d., plus 6s. 6d. per Native Surveyor plus 14s. 6d. per each additional European.

For details of loads *see* para. 52 (Tables I. and II.).

(c) *A Trigonometrical Camp*—

1 Surveyor (Camp Officer).
3 European Surveyors.
2 Native Assistant Surveyors.
2 First-class Headmen.
3 Second-class Headmen.
3 First-class Light-men.
2 Second-class Light-men.
80 Carriers.

Daily cost, excluding Surveyors, £4, 14s. 3d.

TYPICAL RIVER IN SCRUB COUNTRY.

MANGROVE FORESTS.

TYPICAL "BUSH" COUNTRY.

IN THE PALM BELT.

MOVING CAMP.

(d) *A Field Camp for Theodolite Traverses*—

1 Surveyor (Camp Officer).
1 Native Surveyor.
2 Second-class Headmen.
30 Carriers (including 5 chainmen).

In beach traverse or country where little clearing is required the carriers should be reduced to 20.

Details of loads and working parties are given in Tables XII., XIII., and XIV., para. 52.; also *see* para. 161 (b).

(e) *A Levelling Camp*—

1 Native Surveyor (Camp Officer).
1 Native Surveyor.
1 Second-class Headman.
18 Carriers (including 6 chainmen).

Daily cost, excluding Surveyors, £1, 1s. 3d.

Details of loads and working parties in para. 52, Tables IX. to XI.

(f) *Headquarter Camp*—

1 Clerk.
1 First-class Headman.
8 Hammock Boys.
30 Carriers.

Daily cost, excluding Clerk, £2, 0s. 6d.

Loads, and Organisation of Field Camp Carriers.

52. (a) The smooth and efficient working of a field camp depends very greatly on the way in which the camp officer organises his carriers for their two chief duties, viz., shifting camp and clearing lines. To prevent these duties clashing, the number of loads must be kept down to the minimum, only sufficient being carried for immediate use and the remainder being kept in the field depôt; and foresight must be exercised by the camp officer in planning future work and shifts.

(b) The loads in a field camp are of two kinds: (1) The camp office, which includes survey instruments and stores; (2) the personal loads, which depend on the number of surveyors.

TABLE I.

Camp Office Loads.

Field books, auxiliary sheets, records	2
Instruments, drawing board, etc.	1
Field sheet box	1
Two deed boxes of stationery, accounts, etc.	1
Banderoles, plane table and compass tripods, umbrella, map case, etc.	1
Matchets, spades, picks, cleaning material	1
Medicine case	1
Total Camp Office Loads	8

(c) Table I. does not include a theodolite, which is brought up from the field depôt when required.

A few survey beacons are distributed among the above loads, the remainder being kept at the depôt.

(d) *Group Camp Office.*

Add to Table I.:—

Office tent	2
Draftsman's tent	1
Draftsman's chop box and cooking utensils	1
Draftsman's clothing, table, and chair	1
Draftsman's bed	1
Drawing-table top	1
	7

TABLE II.

European and Chief Native Surveyor. Personal Loads.

Tent	2
Bed and bedding	1
Bath containing clothing	1
W.A. uniform case and table	1
Cooking utensils	1
Water carrier (full)	1
Canteen, chair, table	1
Chop boxes	2
Lamp and kerosene	1
Total	11

(e) When the surveyor is not a camp officer an extra carrier must be added to Table II. for one load of survey stores.

When travelling light on special occasions, two carriers can be saved by carrying only the outer fly of the tent and one chop box.

The two chop boxes contain enough food and drink for two weeks, and can be replaced by boxes brought by the weekly messenger from the field depôt, where the surveyor should arrange his stores in numbered boxes, each containing a week's supply. As the duration of the field season is known, the packing should be done before leaving Headquarters. Any rearrangement necessary can be effected when the field depôt is visited.

TABLE III.

Native Surveyors (First to Fourth Class). Personal Loads.

Tent	1
Chop box	1
Bed, chair, and lamp	1
Table and survey stores	1
Clothing	1
Total	5

(f) A first-class native surveyor is allowed a sixth load. All native surveyors require a water carrier when travelling in an unusually dry country.

(g) *Working Parties.*—It is necessary here to analyse the working parties required for the various classes of survey, in order to lay down some principles on which camp officers should act when shifting camp at the same time as continuing their survey.

TABLE IV.

Working Party. For Secondary or Tertiary Compass Traverse.

(1) Front banderole	1
(2) Back banderole	1
(3) Plane table	1
(4) Steel band	2 (chainmen)
(5) Books, instruments, umbrella, and water bottle	1
(6) Painting and blazing trees	1
(7) Extra man on steel band	1 (chainman)
Total	8

(h) For primary traverses two extra chainmen are required for the short band.

TABLE V.

Rope Traverse Party.

Rope (front)	1
Rope (rear)	1
Plane table	1
Books, instruments, etc.	1
Painting and blazing trees	1
Total	5

TABLE VI.

Disposal of Carriers. (Camp Pitched.)

With camp officer on traverse (Table IV.)	8
Preparing lines under headman	9
Camp, sanitary, messenger, or sick	2
Total carriers as in para. 51 (b).	19

(i) Any native surveyor belonging to the camp can carry on his work as in Table V.

TABLE VII.

Disposal of Carriers in Shifting Camp.

With camp officer on traverse (Table IV.)	8
Shifting camp under headman	11
Total carriers as in para. 51 (a).	19

(j) With regard to Table VII. there are nineteen loads to be carried, some of which are light owing to the fact that certain stores are being used by the traverse party, and the camp can be shifted up to 7 miles as follows: The eleven carriers march off with eleven loads (including the tent), leaving the policeman in charge of the remaining eight loads. On arrival at the new camping ground eight carriers return for the other loads, leaving three under the headman to pitch the tent, prepare a kitchen for the cook, make sanitary arrangements, etc. This system necessitates eight of the carriers making a journey of 21 miles, but 7 of these miles are covered without loads.

(k) If the camp officer has thought out his movements sufficiently he should seldom find it necessary to shift camp for more than 7 miles. When this is necessary, survey work need only be suspended for half the day. If the camp is to be shifted for 15 miles, the new camping ground should certainly be reached by 11 A.M., all the men carrying loads, and work can begin at 1 P.M. On these occasions, however, it may be sometimes advisable to give the carriers a half day's rest.

(l) *Native Surveyors Shifting Camp.*—In the case of Table VII., if one native surveyor only is present with the field camp, he can transport his camp with his five men and work the remainder of the day. If two native surveyors are present, one could carry on with the rope traverse all the day while the other shifted the stores by a double journey.

(m) *Native Surveyors on Detached Duty.*—When a native surveyor is sent off to camp by himself, as should constantly be the case, the camp officer should, *if possible*, spare him from one to three extra carriers. If he has three extra carriers, he can move his camp daily up to 7 miles without interfering with his rope traversing. If, however, these carriers cannot be spared by the camp officer, the native surveyor should shift his camp every second or third day to some place near the end of his completed traverse. *It is a common and very serious fault with native surveyors* to avoid shifting their camps until they are obliged to walk some 5 to 7 miles to the place where they left off work overnight. *Camp officers must be on the lookout for this, and treat all such cases with severity.*

(n) Table VIII., given below, shows how a field camp with two native surveyors can shift camp without any interruption to the work, provided all are engaged on rope traverses and the distance does not exceed 7 miles.

Note.—By para. 51 (b) there would be twenty-nine carriers in this case, and there are twenty-nine loads that can be reduced to twenty-eight owing to the plane tables, ropes, etc., being used by the traversing parties.

TABLE VIII.

Shifting Field Camp.

With camp officer on rope traverse . . .	5
With two assistants on rope traverse . . .	10
Shifting camp by double journey . . .	14
	29

TABLE IX.

Levelling Camp. Loads.

(1) Two native surveyors (Table III.)	10
(2) Field books, auxiliary sheets, etc.	1
(3) Level and plane table	1
(4) Banderoles, compass tripod, umbrella, map case, matchets, spades, picks	1
(5) Stationery box and medicine case	1
(6) Survey beacons, point, etc.	1
Total Loads	15

TABLE X.

Levelling Camp. Working Party.

(1) *With Levelling Party*—	
Level and umbrella	1
Levelling staffs	2
Rope, field books, etc.	2
Blazing and painting trees	1
(2) *With Traverser*—	
As in Table IV., less Items 5, 6, 7	5
(3) *With Headman*—	
Clearing	6
(4) *Camp and Sanitary*	1
	18

TABLE XI.

Levelling Camp. Shifting Camp.

Levelling party (Table X., Item 1)	6
Traversing party (Table X., Item 2)	5
Shifting camp (Table IX., 15 loads, less Item 3 in use) by double journey	7
	18

TABLE XII.

Field Camp. Theodolite Traverse Loads.

Office—	
(1) Field books, auxiliary sheets, etc.	2
(2) Drawing instruments, boards, and miscellaneous instruments	1
(3) Deed box and medicine case	1
(4) Theodolite	1
(5) Plane table, theodolite tripod, and umbrella	1
(6) Banderoles, matchets, spades, picks, and paint	1
(7) Personal, as in Table II.	11
(8) Personal, as in Table III.	5
Total Loads	23

TABLE XIII.

Theodolite Traverse Working Party.

Observing and Chaining Party—	
Chainmen	5
Theodolite boy	1
Station boys	2
Plane table and umbrella	1
Clearing Party, in two Squads—	
Banderole boys	2
Picket boys	2
Axemen (also carry matchets)	6
Matchet men	10
Camp and Sanitary	1
	30

TABLE XIV.

Field Camp on Theodolite Traverse: Shifting Camp.

Observing party, as in Table XIII.	9
Clearing party (one squad only, as in Table XIII.)	10
Moving camp by double journey (23 loads in Table XII. reduced by Items 4 and 5)	11
	30

(o) The foregoing remarks should give camp officers a good guiding line for their organisation of carriers. *The importance of good arrangements for shifting camp cannot be too strongly impressed on all camp officers.*

Field Camps, System of Working in Field Groups, and Duties of Group Officers.

53. (a) In the next paragraph a full description of the methods of field camps working in pairs is given. In open country, covered by triangulation and suitable for plane-table survey, the methods therein described can be adopted from the start. In close country, however, a preliminary operation has to be gone through, viz., the construction of the compass framework, described in paras. 100 and 101, to supplement the theodolite framework.

(b) The best plan would be for each field camp to survey the framework in its own field sheet, but in practice this is seldom found convenient. The traverses forming the compass framework often stretch across two or three field sheets before they can be tied to the main framework, and considerable delay would often be caused by having to wait for the completion of these traverses before the compass framework could be adjusted. The same remarks apply to the construction of the vertical framework of secondary heights.

(c) The group system of working has therefore been adopted, and is roughly as follows:—

Four or five field camps are formed into a field group, and work under the general direction of a group officer. The group officer is

usually an Assistant Director, Topographical Branch, and has his own separate camp, including a draftsman.

(d) During the field recess the group officer is allotted an area of a certain number of standard sheets for topographical survey during the coming field season. He draws up a general programme, which he submits for the Director's approval, and by the time he lands on the coast has his detailed orders written and distributed to his camp officers.

(e) These orders include :—

I. The general programme for the season, including arrangements for field depôts, intercommunication, supply of money, etc.

II. Orders for the execution of the framework and time allotted thereto.

III. Distribution of field sheets, or of blocks thereof, to his camp officers, and time allowed for the completion.

IV. Any orders for special surveys.

(f) On arriving at Headquarters the preparations for the field season (detailed in para. 55) are completed, and the field group moves to the first standard sheet to be surveyed.

(g) The group officer establishes his camp at some convenient place near the centre of the standard sheet, and his camp officers at once proceed to survey the compass framework, simultaneously with which they construct the vertical framework of secondary aneroid heights. The camp officers send in their traverses as each is completed to the group officer, who gradually plots all the framework on the field sheets.

(h) When the survey of the framework is complete the camp officers assemble at the group officer's camp to receive their sheets or blocks (*see* subpara. o) and any further instructions that may be necessary, but they should leave their assistants to carry on with work that will eventually come in useful.

(i) Each camp officer now has his field sheet divided up into large blocks, and at once proceeds to tackle the work of filling in, *bearing in mind the time allotted for its completion.*

(j) At the beginning of the framework survey the group officer may have time to devote himself to some part of the traverse work, but it is more likely that he will find work to do in observing any latitudes required, in fixing secondary heights in conjunction with his camp officers, etc. When the results begin to come in the group officer will have little time for anything else but adjusting the framework. On its completion he should move about among his camps supervising the work, assisting his officers as much as possible with drafting work, and helping those who are behindhand with their work. The group officer cannot expect to find time to do much practical survey work beyond the observation of latitudes and for magnetic variation, the determination of secondary heights, and the checking of sheet edges.

(k) During the construction of the framework camp officers should utilise their trained assistants on the actual traverses, and the untrained ones in any way that will expedite the work.

(l) On the completion of a field sheet it is inspected in the field by the Director with the group officer, names corrected, and the checking of edges verified. It is then sent to England to the publisher through the Headquarter Office.

(m) In arranging their programmes group officers must aim at the completion of the four field sheets forming a standard sheet before another field sheet is started.

(n) A field camp that finishes its work ahead of time should be sent to start the framework of the next standard sheet on the programme.

(o) *Allotment of Field Sheets, or of Blocks only, to Camp Officers.*—In plane-table country always, and in certain cases in forest country, the principle of making a camp officer responsible for the whole field sheet after the framework has been made should be observed by the group officer. It is a more satisfactory system from the camp officer's point of view, and in plane-table country, where the survey is actually carried out on the field sheet itself, is the best system.

In forest country, however, it is generally advisable to allot blocks to each camp officer. The actual survey has to be made on an auxiliary sheet on a larger scale than the field sheet scale para. 64, (e), and then reduced to the field sheet. Consequently there is no reason why the group officer should not allot blocks to his camp officers, who could survey them on the principles described in para. 200 (f) on any convenient scale, and then send the auxiliary sheets to the group officer for reduction to the field sheet. This system has the advantage of—

I. Reducing the drafting work of a camp officer.

II. Minimising any disadvantages due to his being a bad draftsman.

III. Keeping the group and field camps concentrated in a small area, thereby facilitating control and intercommunication.

IV. Facilitating the comparison of edges, for these are formed by the traverse framework.

The chief disadvantages are that—

I. The field sheet is not the work of one camp officer. This is not very important, so long as it is known who is responsible for each block.

II. The amount of work devolving on the group officer, who, however, has a draftsman.

(p) *Remarks on Blocks.*—Care must be taken not to give the camp officers scattered blocks, as this would lead to frequent changes of camp.

The group officer should bear in mind, when designing the framework mentioned in (e) II., that the camp officer can further subdivide the blocks for the work of his assistants. The principles mentioned in para. 200 (f) should be observed.

Note.—A $3\frac{1}{2}$ minute square is about $20\frac{1}{2}$ inches square on the 1 : 12,500 scale, and is therefore just too large for one auxiliary sheet on the Mark I. plane table, but there is no reason why the block allotted to the camp officer should not be 7 or 8 minutes square and shown on several auxiliary sheets, as long as the joins of those sheets are clearly marked.

In forest country the group officer should endeavour to arrange his framework so as to coincide as nearly as possible with the edges of the field sheets. This is especially necessary in the case of those edges lying next to a field sheet which is not in the programme for the current season, when the framework should preferably lie outside the edge of the sheet under survey.

Group officers must keep up to date a rough map or diagram showing subdivision of sheets into lettered blocks, progress of survey, and positions of field camps. A copy of this, showing blocks and lettering, to be given to the Director at the beginning of the season.

(q) *Mutual Responsibilities of Group and Camp Officers:—*

I. The group officer is in general command of all the field camps in his group.

II. He receives all the camp officers' mails and correspondence, and issues them by means of the field camp weekly messengers, para. 84 (a).

III. He receives and issues all money remittances, and camp officers apply to him for money.

IV. All technical instructions to camp officers are given by or through the group officer.

V. The group officer takes no responsibility for the stores or accounts of his field camps, but it is his duty to inspect the accounts and records of his camp officers, and to see that they are kept up to date.

VI. All stores and accounts, and correspondence connected therewith, are between the camp officer and the Director direct.

VII. Camp officers have their own field depôts, to which they send for stores when required. Wherever possible the field depôts of all the camps in a group are combined, but in these cases great care should be observed in labelling the various stores to prevent mistakes in issuing.

Field Camps to Work in Pairs.

54. Owing to the presence in each field camp of only one European and to the nature of the climate, it is advisable that the field camps should work in pairs after the completion of the framework as far as possible, and camp officers must collaborate and make every effort to carry out this principle while keeping in view the necessity of each field sheet being the work of one field camp.

There are four systems which either completely or partially fulfil the above conditions, and which are recommended as guides, but none of them are satisfactory or easy to work in forest country.

In Fig. 1 the bounding graticules of the standard map sheets are shown by hatched lines, and those of the field sheets (numbered I. to X. in the centre) by thin lines. The chain dotted line represents the boundary of the country. Nos. 1 and 2 Field Camps are at work.

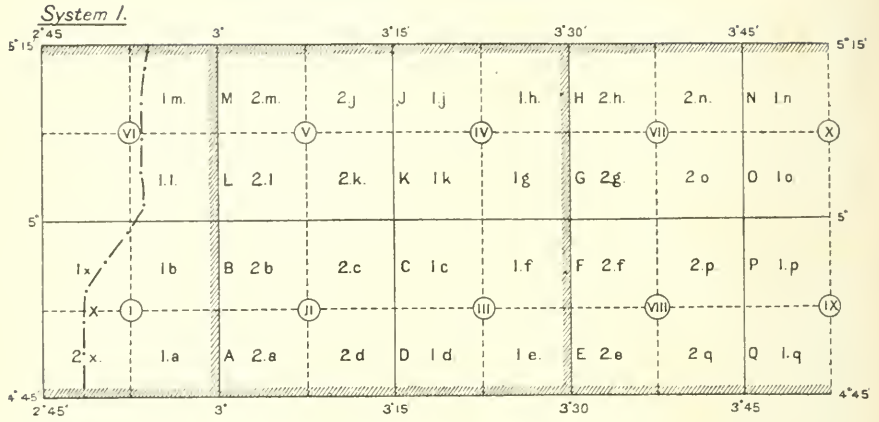
First System.—The two field camps start by camping at some convenient place as near A as possible. No. 1 Field Camp surveys the area 1a, No. 2 Field Camp surveys the area 2a. Both camps move to B. No. 1 surveys 1b, No. 2 surveys 2b.

Working on the above system the field camps, working successively from C, D, E, F, G, H, J, L, M, N, O, P, Q, complete the whole area allotted to them.

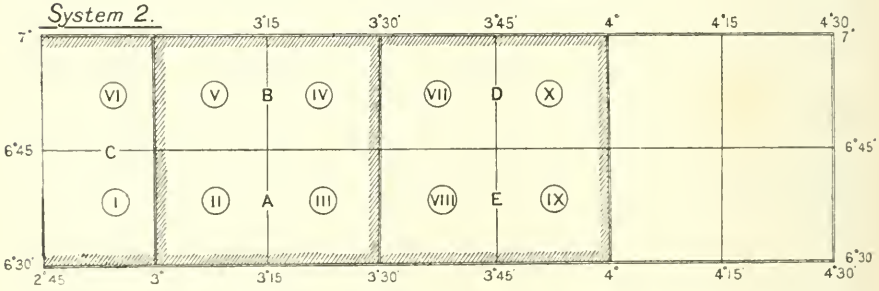
Note 1.—In order to obtain a simultaneous start from A, the two field camps should divide the work of surveying the small area lying west of the meridian 3, viz., 1x and 2x, working from the point X. As this is on No. 1's field sheet, the camp officer of No. 2 will carry out No. 1 camp officer's instructions while on area 2x.

—Fig. 1.—

General System of working Field Camps.



—Fig. 2.—



(I) (II) (III) (IV) etc., are the numbers of the Field Sheets, in the respective centres of which they are placed.

A, B, C, D, etc., are the Camping Grounds.

1, 2, 3, etc., are the numbers of the Field Camps.

1a and 2a are the areas respectively surveyed by Field Camps Nos. 1 and 2 when camped at A; 1b and 2b when camped at B, etc.

The hatched lines are the Bounding Graticules of the Standard Sheets.

The unhatched lines are the Bounding Graticules of the Field Sheets, which are divided into quarters by the dotted lines.

The chain dotted line represents the Boundary of the Country.

Note 2.—The completion of Field Sheets II. to V. before other field sheets are started is aimed at in order to get the standard sheet thus formed ready for publication as soon as possible. Sheets I. and VI. will probably be included in this standard sheet, though if the boundary was farther west a separate standard sheet would be necessary.

Note 3.—Each field sheet (except I.) is the work of one field camp, but the standard sheet is the work of two. There is no disadvantage in this.

Note 4.—The distance from the camping place of the farthest point in each area is roughly 10 miles, and, as there is no objection to the field camps being separated for a few days, camp officers will occasionally find it convenient to camp apart for a time at places inside their field sheets to avoid long journeys before and after work.

Note 5.—Besides avoiding loneliness by camping in pairs, camp officers are able to compare and check their work on the bounding lines of their field sheets. Also *see* para. 67 (f).

Note 6.—It will be noticed that the complete area surveyed by the two camps amounts to about eight field sheets, but that only one standard sheet is completely ready for publication, a shortage which is rectified automatically in the following season, or by the employment of a special field camp to complete the eastern portions of the Field Sheets IX. and X.

Second System.—This is probably a better system for more open country, where surveying is quicker, but is also applicable to forest country (*see* Fig. 2).

(a) Field Camps 1 and 2 survey Field Sheets III. and II. respectively from A.

(b) Move to B and survey IV. and V.

(c) Move to C and survey VI. and I., etc.

Note 1.—If a special camp is put on I. and VI., Field Camps Nos. 1 and 2 can complete Field Sheets II. and V. and VII. to X. in the season, *i.e.*, two complete standard sheets.

Note 2.—The maximum distance of work from camp is about 20 miles, and would necessitate the camp officers camping apart for longer periods when temporarily camping at distant points in their respective sheets.

Third System.—Each field camp surveys the area covered by its field sheet from some convenient central spot or spots. This system is probably more rapid but has the disadvantage of loneliness, the camps being about 15 miles apart. By beginning work on the outer edges of their field sheets and working towards each other the camp officers would be able to camp together for about a week when nearing the completion of their field sheets.

The Fourth System involves longer periods of absence (*see* Fig. 2). Starting at the centre of the standard sheet, No. 1 works round Sheet III. clockwise, No. 2. round Sheet II. against the clock, both filling in their field sheets, and eventually meeting and checking overlaps at the original starting-point. Again starting, No. 1 works round IV. against the clock and No. 2 round V. clockwise, until they finally meet again at the original starting-point on completion of the four field sheets.

Preparation for Field Season.

55. At the beginning of the field season a survey circular will be issued from Headquarters detailing the programme of the work for the season, the names of group and camp officers and their staffs, and the strength of their field camps, the dates of starting work, and any special information likely to be of value.

On receipt of the survey circular a camp officer will :—

(a) Obtain his headman, chainmen, and carriers from the Chief Assistant. There will seldom be sufficient old hands to complete the party, so new men must be engaged (*see* para. 34).

(b) Draw survey stores, and despatch them either to his field depôt or camping place under the headman and an escort of at least one policeman. Considerations of time and the further transport required will influence the surveyor in deciding whether the gang should return, in which case the policeman and a headman must be left in charge of the camp. Should the distance be too great for the gang to return, the camp officer should apply to the Director for permission to engage extra men to take him out if the railway is not available. For Railway, *see* para. 26; for Field Depôts, *see* paras. 27, 28, and 56 (f).

(c) Confer with his group officer, and arrange his plans for carrying out the latter's orders.

(d) Mount his field sheets (para. 58).

(e) Prepare his field sheets (paras. 59 to 62).

(f) Plot the framework on his field sheets (para. 60).

(g) Get as much information as he can about the country he is going to from people who have been there, route books, and civil list; get any existing map of the district, and take extracts from any computations likely to be of use to him.

(h) Ascertain the nature of the communications, the existence of District Commissioners (and names), medical officers (Government and otherwise), post offices and other Government stations, the best form of transport, the food resources of the country, and any other information likely to be of value.

(i) Draw medical stores from Chief Assistant. The camp officer should see the medical officer if he wishes any special preparations made up.

(j) Test all theodolites, compasses, barometer, and steel bands, ascertain error index, etc.

Note.—The above preparations will, if carefully carried out, conduce to the efficiency of the work and the comfort of the field camp, and should not take more than a week. For use of Field Note-book in foregoing preparations *see* para. 63.

Drawing, Safeguarding, and Returning Stores.

56. (a) The equipment of a topographical party depends on the nature of the work, the character of the country, and strength of the party. The numbers of each item on the lists given in Appendix IV. are not to be exceeded without authority, owing to the danger of draining the survey store of any particular article before all the camps are outfitted. General Regulations for Stores are given in para. 49.

(b) At the beginning and end of the field season the Chief

Assistant will superintend the actual issue and return of the stores.

(c) *Indents for Stores* will be made out by the camp officers in the usual way on Survey Form No. 6.

(d) Before signing for the stores the camp officer should satisfy himself as to their condition, any damage thereto being noted and initialled by the storekeeper on both copies of the indent.

(e) *Camp officers are responsible* for the care of all stores issued to them, and should therefore obtain a receipt from assistants to whom they may have cause to issue them.

(f) *Field Depôts.*—To do away with the disadvantage of topographical parties having more loads always with them than carriers, field depôts will be formed at convenient places along the railway, the Niger, and the coast to contain the supplies of the field camps in the vicinity. At the beginning of the field season the camp officer will despatch all his stores to his field depôt. Any subsequent requirements will be sent by Headquarter arrangements by road, rail, sea, or river (*see* paras. 27 and 28).

(g) "Stores and public property should not be kept in a closed tent with a single sentry outside, for such an arrangement is unsafe and unfair to the man on guard. The most secure method of guarding property is to collect it at an open spot, from which the sentry can have a clear view on all sides; the articles should be raised above the influence of damp ground and white ants by means of wooden trestles, stones, or bricks. Delicate instruments liable to injury from exposure can be protected by waterproof sheets. When the strength of the escort is insufficient for furnishing a double night sentry the chain boys of the camp must take their turn on such duty."—(S.I.).

(h) Every precaution should be taken against damage to, or loss of, Government property by theft, fire in tents or houses, and in transit by post, boat, or rail. Camp officers are authorised to pay insurance premiums after conferring with the Director (*see* Survey Circular No. 131, 1910).

(i) "It should be specially noted and impressed on all assistants and subordinates that survey instruments, such as theodolites, levels, plane tables, etc., should, except in very exceptional circumstances, always be carried by the carriers and not on carts, mules, or other animals. Should it be unavoidable to carry theodolites or other delicate instruments in carts, a layer of branches placed under the boxes will be found to be an excellent substitute for springs, and prevent injury from jolting."—(S.I.).

(j) *End of Field Season.*—Stores will be returned and dealt with at the end of the field season, as detailed in para. 57.

Closing Field Season.

57. Owing to the necessity of keeping the topographical parties in the field until the last possible moment, only a few days before embarkation are available at Headquarters for paying gangs, settling accounts, returning stores, etc. In view of the confusion that will result if all the instructions contained in this paragraph are not punctually and methodically carried out, camp officers and others concerned are warned that no deviations from the published programme are allowed.

The following general procedure is adopted in closing the field season :—

I. About a month before the close of the season a survey circular is published, giving a programme of the dates on which each field camp will return to Headquarters, pay off, return stores, etc., and the information required by V. (e).

II. *Arrival.*—Camp officers will report their arrival personally to the Director on the days given in the programme.

III. *Paying off Gangs.*—Camp officers will inform the Director a week previous to their arrival of the amount they will require to pay off their carriers. On reporting to the Director each camp officer will receive a cheque, which he is responsible for cashing at the bank in time to start payment at 9 A.M. on the date given. Complaints of carriers on paying off are to be referred to the Director.

IV. *Accounts.*—Camp officers are reminded that, on the day marked for their accounts, they are expected to produce their cash books, carriers' books, and vouchers all balanced up and complete. *See* para. 39 (i) to (k), (m) to (p), and para. 41 (Class E).

The Director will take accounts personally in the Headquarter Office.

No item of expenditure will be passed without a voucher correctly drawn up to support it.

V. *Stores.*—At the times stated in the programme the camp officers will have their tents pitched and all stores ready for inspection by the Deputy Director assisted by the Chief Assistant in the survey compound.

Stores will be dealt with in the following manner :—

(a) All stores will be checked with the store ledger. Cases of deficiencies will be referred to the Director for decision.

(b) All stores fit for use in the next field season will be kept on the camp officer's charge, and will be neatly placed in the compartment allotted to him, so that the storekeeper can get at them for cleaning, oiling, etc. The camp officer will obtain a receipt for the stores so left, and the Acting Director of Surveys is responsible that these stores are not used during the camp officer's absence.

(c) All instruments requiring repair in England will be kept on the camp officer's charge, and will be packed and taken by him personally on the ship. They will be handed over at the Survey Office in London on a date notified by survey circular. A list of the instruments and the general nature of the repairs will be handed over with the instruments.

Theodolites and other delicate instruments are to be taken as personal baggage, and on no account should be placed in the hold. Arrangements will usually be made for the use of the baggage room on the ship, and any excess baggage charges should be referred to the Director or the officer in charge of the party on board.

The Director will make arrangements for the repair of stores in London, and will notify the camp officer of the date on which they should again be taken over for the outward voyage.

(d) All stores unfit for use next season will be struck off the camp officer's charge and taken on charge by the storekeeper.

(e) *Leaving Stores at Field Depôts.*—At the end of the field season a camp officer will, if he is working in the same district again next

season, leave all heavy stores not requiring repair, except theodolites and other instruments and plane-table boards, at his field depôt or some other convenient place approved by the Director. Such stores should be left with a Government official or some reliable chief, and should be placed in a masonry building whenever practicable. When left in wood buildings or huts proper arrangements should be made for their safe custody. The list of camp officers who will leave their heavy stores at their field depôts will be notified by survey circular.

VI. *Stores for Next Season.*—Each camp officer is held responsible for all stores required by him in the next field season. With this object in view, therefore, he will hand the Chief Assistant a list of the stores required by him to bring those mentioned in V. (b) and (c) up to their full complement. In the case of field books, auxiliary sheets, forms, pencils, etc., he will base his requirements on the number of field sheets that he will be called on to survey next season and the strength of his party.

The lists of these fresh stores to be handed to the Chief Assistant by 11 a.m. on the day following that on which stores were inspected.

VII. *New Stores.*—The Chief Assistant will mark on the lists mentioned in VI. the number of items he can make good from the survey store, and the balance will form the basis for the purchase of stores in England. During the voyage the Chief Assistant will make out the full list of new stores required.

VIII. *Work at Headquarters.*—In addition to the duties before laid down in this paragraph camp officers will have a large amount of work to do in completing their field sheets, records, and reports. Much of this work will probably have to be done on the voyage and in the London office, but the more that can be done before landing the less call will be made on the camp officer's time in England. Arrangements for quarters and drafting offices at Headquarters for the various camp officers will be notified in survey circular.

IX. *Dealing with Field and Auxiliary Sheets and Field Books.*—The following will be taken to England by each camp officer packed for use on the voyage :—

(*a*) *All Field Sheets intended for Publication.* (Not to be removed from plane-table boards.)

(*b*) *All Field Note and Village and River Field Books, and Diaries* referring to those field sheets intended for publication.

(*c*) *All Field Books* of every class, *Auxiliary Sheets*, or other records, the contents of which have not been fully transferred to the field sheets.

(*d*) *Camp officers will take particular care that they take home with them all the books and records mentioned in* (*c*), and that all field sheets, books, etc., are packed in such a manner as to be safe from damage by water, and plainly labelled with their own and the ship's name and destination.

(*e*) All field sheets should be complete before embarkation, as described in paras. 74 and 76. In cases where this is not possible special care must be taken to see that the edges are complete and carefully compared with the edges of adjoining sheets before embarkation. Camp officers must be on the look-out for cases when details of villages and rivers on the edge of their field sheets are dealt with in the village and river field books of an adjoining sheet.

and be careful to see that he has the necessary details in his reference tables.

(*f*) Attention is directed to the details necessary in reference tables, para. 76 (b).

X. *The Annual Field Camp Report and Reports on Native Surveyors*, described in paras. 86 and 82, should be completed before embarkation. Where this is impossible, the camp officer is responsible that he has all the information necessary for their compilation on the voyage, in which case the report must be completed one week after embarkation.

XI. *General arrangements for embarkation* will be made by the Chief Assistant and published in survey circular.

58. Each camp officer is generally sent into the field with four field sheets mounted on plane-table boards.

Mounting Field Sheets.

"To mount a field sheet get some fine linen about three inches larger in each direction than the board, damp this slightly, and paste it on the *underside* of the board only. The paste should be made of the finest flour available; corn-flour is the best. Then take a piece of drawing paper the same size as the linen, damp it on the wrong side, paste the linen all over and smooth the paper down on to the linen by pressing from the centre outwards rather than by rubbing. Paste also the overlap of paper on the underside of the table. Put in a few pins temporarily on the underside; these can be removed in about twelve hours, when the table will be ready to work on.

"When the work is finished and the field sheet is removed from the board its edges should be bound with tape.

"The reasons for mounting paper on linen are that it gives a good surface to work on and renders the paper less liable to be torn, and somewhat less liable to be affected by expansion caused by wet and damp."—(*Close.*)

The paper when thus mounted should be allowed to dry gradually. Care must be taken to mount the paper right side uppermost; the side on which the watermark reads correctly is the right side.

59. Field sheets on a scale of 1:62,500 should occupy 15′ of latitude and 15′ of longitude; for larger scales a corresponding amount proportional to the scale. The plane-table boards being 24 by 20 inches, a sufficient margin is left for overlap. Field sheets are given serial numbers from 1 upwards at Headquarters. Charts of these numbers are kept in the Headquarter and Topographical Offices.

Area and Number of Field Sheets.

60. (a) As soon as his mounted field sheet is dry the surveyor will plot on it the 15′ graticule, divide this up into 5′ divisions, and plot the trigonometrical and traverse stations on the survey framework by co-ordinates checked by distances.

Plotting Graticules and Framework.

(b) All details of the triangulation and traverses of the framework will be obtained in the Topographical Office, where arrangements will be made for the accommodation of the

camp officers, all routine work being suspended and every assistance given by the office to facilitate the work of preparation for the field.

(c) *On no account are field books, charts, co-ordinate sheets, or other records to be taken out of the Topographical Office without the authority of the Director.*

(d) A certain number of fixed points on the framework should be plotted outside the graticule in the margin allowed for overlap, as they are essential in completing the topographical survey on the outer edges of the field sheet. The graticule must therefore be placed on the paper so as to include the most useful of these points: there is no necessity for it to be parallel to the edges of the table. The best way to get the approximate position of the graticule is to enlarge the graticule roughly from the framework chart to the scale of the field sheet, and pencil in the points lying just outside it. Then place the tracing paper on the field sheet and shift it about so as to allow the desired outer points to come on the board. It will not generally be possible to place on the field sheet all the external points that might be useful, but in open country every effort should be made to include some well-defined distant point, such as a hill peak, to work on.

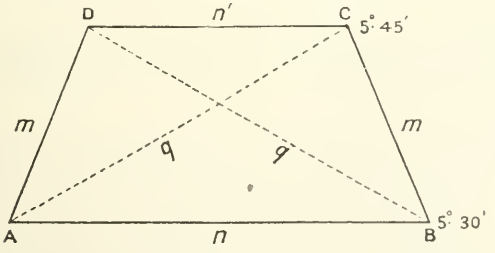
(e) The number of the field sheet, ascertained from the Field Sheet Chart in the Topographical Office, is printed in bold black letters "F. S. No. ..." in the right hand top corner (*vide* Conventional Sign Plate for Field Sheets).

(f) For notes on plotting framework *see* para. 89.

Projection of Graticules.

61. The system of projection to be used is the "rectangular polyconical," and the method is fully described in the pamphlet *Tables for the Projection of Graticules*, published by the Topographical Section, General Staff, War Office. Owing, however, to the proximity of the Equator, no useful object is attained in adopting the full procedure therein described, and the following system will be used as an adaptation of the tables referred to. The figures are given in Table VII. at the end of the *Handbook*.

FIG. 3. GRATICULE DIAGRAM.



Example of method of plotting field sheet graticule *between 5° 30' and 5° 45' N.* Scale 1 : 62,500.

From Table, m = 17·414 inches.
n = 17·451 „
n = 17·444 „
q = 24·650 „
Plot AB = n = 17·451 „
With centre A and radius q } obtain C.
„ „ B „ „ m }
Similarly with centre B and radius q } obtain D.
„ „ „ A „ „ m }
Check CD = n′ = 17·444 inches.
Divide AB, BC, CD, DA each into three equal parts to obtain 5′ squares.

62. All trigonometrical and traverse points must be plotted by the camp officer, and when complete carefully tested by the group officer, and both should then sign their names on the "Record Slip,"[1] which should now be pasted on the back of the board. As a check on the plotting, trigonometrical points should also be checked by their distances, as obtained from the computations.

Checking and Inking in Points.

Record Slip for Field Sheets.

Projection by.....
Do., examined by.....
Plotting by.....
Do., examined by.....
Surveyed by.....
Commenced.....
Finished.....
No. of working days.....
No. of plane-table fixings.....
No. of clinometric heights.....
Contoured by.....
Area surveyed.....sq. miles.....
Tested by.....
Length of test lines.....
No. of test *in situ* fixings.....
Edges adjusted by.....

.....Group Officer
.....inch. No... ..... Field Camp.

The plotted points are then inked up, according to the Conventional Sign Sheet, being given their proper numbers and a reference table neatly drawn in the field note-book.

63. (a) In addition to preparing his field sheets a camp officer will enter in his field note-book all information about the framework that is likely to be of use to him.

Field Note-books and Reference Books.

(b) The note-book will begin with the table mentioned in the last paragraph, giving the reference number, name, height, and co-ordinates of all trigonometrical points, and of those stations on the traverse lines of which

[1] The Record Slip is that adopted by S.I.

he is likely to make use. These traverse stations will be only those which are marked by beacons or are capable of identification on the ground. (It may occasionally be useful to take a copy of the rectangular co-ordinates of some portion of the traverse lines referred to one of the traverse stations above mentioned.) Sufficient notes must be appended to this table, extracted from the original field books of the framework survey, to identify the trigonometrical and traverse points.

(c) Care must be taken to note whether the height represents the bottom or top of an object; if the latter, the height of the object above the ground should be entered. If this is not obtainable from the records, it should be measured by the surveyor when he reaches it and entered in the reference table.

(d) The field note-book will be of further use to the camp officer for jotting down miscellaneous information of a technical character, such as the list and errors of his instruments, para. 55 (j); the list of beacons erected, para. 83 (f) and (j); information about the country, para. 55 (g); list of beacons he has to examine, para. 83 (j).

(e) *Reference Books.*—A camp officer is apt to rely too much on his memory when he requires any particular plan or book for reference. As each field camp uses about 200 auxiliary sheets and field books during the season, a book must be kept as a "Reference Book," in which can be at once found the number of the auxiliary sheet or field book of any particular traverse or locality.

The Reference Book will be kept in the form shown below, and the column of remarks should contain notes *re* adjustment.

The Reference Book must be kept strictly up to date.

Item.	*Locality.*	*No. of Auxiliary Sheet.*	*Field Sheet No.*	*Class of Survey.*	*Field Book No.*	*Remarks.*
10	AWBA to IRO	7	25 & 26	T.C.T.	3	
11	Tree 15 on No. 10 to ITAKU	19	25	Rope	30	
12	OGUN RIVER, IRO to BARAGUN	29	25	Water	42	
13	Area enclosed by IJU-AWBA-ASHA - OJO roads	30, 31	25	Sound and Pace	49-53	

Auxiliary Sheets.

64. (a) A camp officer should take into the field from 50 to 200 "auxiliary sheets." An auxiliary sheet is a sheet of drawing paper, usually of the sectional type, mounted on linen. It is usually pinned on a spare plane-table board, but, if it is considered desirable, it can be mounted by slightly damping the cloth on the back, laying it in the plane-

table board, and pasting the overlap underneath. Fifty sheets should be enough for open country, 200 for forest country with many roads.

Uses.

(b) A surveyor on traverse work, especially with compass in forest country, can plot his daily work as he goes along, thus saving injuring the surface of his field sheet by the use of rubber when adjustments are necessary.

(c) Native surveyors who are sent out by the camp officers to fill in certain areas in the forest country, or to execute certain definite traverses, can use an auxiliary sheet, the work being later transferred to the field sheet.

(d) Auxiliary sheets are very useful when, before taking the field, it is necessary to plot a long line of traverse framework on the field sheet; this can first be done on the auxiliary sheet, the work being expedited by the sectional paper, and then reduced to the fixed points on the field sheet. This course is recommended, as the same auxiliary sheet can afterwards be used in making blocks in conjunction with compass traverse framework.

(e) The use of the auxiliary sheet is further advantageous in that it permits the use of larger scales than that of the field sheet. In the forest belt of Southern Nigeria the shortness of traverse rays is such that they cannot be plotted on the field-sheet scale. In the majority of cases it is practically impossible to plot compass traverses on a less scale than 1 : 12,500; in the case of paths or small streams winding through exceptionally heavy bush the scale can advantageously be increased to 1 : 6250, but this should if possible be avoided. These plots can be reduced either direct on to the field sheet or on to the tracing paper first, whichever is the more convenient. *See* paras. 102 (d) and 104 (c).

(f) A title, scale, and north point, and the numbers of the traverse, river, and village field books used should always be written in ink on each auxiliary sheet, also a brief account of any adjustment found necessary. In the top right-hand corner will be placed the number of the auxiliary sheet and that of the field sheet for which it has been used. Surveyor's signature must be written on all auxiliary sheets, followed by the number of the field camp to which he belongs.

(g) The auxiliary sheet must be neatly but not elaborately inked in every day. It forms an important record.

(h) One auxiliary sheet may contain several lengths of road. The surveyor will find that he will save himself an immense amount of time and trouble, in the case of primary and secondary compass traverses, if he makes the subsections of his co-ordinates correspond to the lengths of road on the auxiliary sheet. This facilitates reduction and adjustment, and is fully described in para. 102 (b), (c), and (d). The names of villages, rivers, etc., must be entered fully on the auxiliary sheet, as well as the "reference number."

(i) A valuable use that can be made of the auxiliary sheet is described in para. 200 (d) to (f).

65. (a) "A camp officer is entirely responsible for the work entrusted to him. Except for the few hours he has to attend to his

returns prior to their despatch to his group officer or Headquarters and to the distribution of pay he should be constantly at work. He should be a man of tact and resource, and of active habits, punctual in the submission of accounts and returns, and methodical in all matters connected with the management of his camp."—(S.I.)

Duties of Camp Officers.

(b) The camp officer should take frequent opportunities of checking the work of his field camp, and instructing his subordinates in drawing and mapping. *No pains should be spared in training newly joined assistants in the theory, as well as in the practical use, of survey instruments; and impressing on them the great importance of accurate chaining, the worthlessness of slipshod work, and the absolutely essential value of truth.* It is impossible to over-estimate the ultimate value of time spent at the beginning of a field season in the practical training of young assistants. An assistant, in nine cases out of ten, becomes what his camp officer makes him.

(c) "He should see that his subordinates are properly provided with instruments, stationery, medicines, and camp equipment, and furnished with ample data on which to base their work, together with full instructions (written, if necessary) as to the locality, method of procedure, and quantity of work expected of them, and that they are fully capable of performing their work in the field. He should keep his assistants duly informed of the various survey circulars as they are issued. He should satisfy himself that they study their handbooks, and keep them up to date, and he should examine them at the end of the field season to ensure their keeping up a sound knowledge of their profession."—(S.I.)

(d) When a field camp has as many as three or four fully trained native surveyors, three or four detached camps may have to be formed, and the camp officer's time will be chiefly occupied in supervising and checking, so that he will only be able to execute personally the more important parts of the work. A camp officer can efficiently supervise six plane-tablers, or four traversers in forest country, working on the 1 : 62,500 and 1 : 12,500 scales respectively. With only one or two native surveyors, the camp officer's chief work is surveying, varied by supervision and checking.

(e) "Topographical surveyors have generally many opportunities of collecting statistics about the country under survey, and it is most important that they should avail themselves of such chances, especially in little known districts. The camp officer should impress upon his assistants the great value of information of this kind when intelligently collected and systematised."—(S.I.) The kind of information likely to be useful is given in para. 71.

(f) One of the most important duties of a camp officer is to keep his field camp in such a state that it can be handed over to another camp officer at a moment's notice. To enable this to be done, it is insisted that all camp officers should keep their work and accounts up to date, and all their papers, forms, and drawings neatly docketted. In fact, every field camp must always be up to date, and the fact that it is so reflects credit on the camp officer, and leads to efficiency and consequently to promotion.

(g) The importance of the technical training of native assistants by camp officers has already been pointed out. Their moral training

is equally important, and every effort must be made to impress on them the value of honest work and truth. An unfaithful surveyor who fakes his work is the cause of more trouble and expense than any other form of obstacle encountered in mapping the most difficult country in the world.

The importance of this training cannot be too strongly impressed on camp officers. On the first case of faking coming to their notice, they should point out the serious nature of the offence to the delinquent, but the second case must be reported to the Director.

Camp officers should deal with occasional mistakes lightly but firmly, but frequent mistakes point to carelessness and must be reported. Mistakes and faking do not come in the same category, and camp officers must be careful to observe this principle in their treatment of offences.

(h) Camp officers must impress on their assistants the necessity of early rising, so as to comply with the instructions contained in para. 87 (Working Hours in the Field). Also the necessity of frequent short shifts of camp to avoid long walks in the morning to reach the place at which work stopped over-night, and the fact that this can be done without interfering with work. *See* para. 52 (l) and (m).

Both late rising and disinclination to shift camp are common faults in native surveyors, and must be firmly checked.

66. (a) The camp officer must look carefully after the health of his camp. He must see that his assistants are supplied with suitable and sufficient medicines, and written directions for their use.

Health of Field Camps.

(b) All serious cases of illness should be at once reported to the nearest doctor and to the group officer. If he is capable of being moved, the patient should be sent for treatment to the nearest hospital.

(c) Medicine chests must be returned to store every year to be refilled for the next field season. Useful medical hints will be found in *Hints to Travellers* and the local medical handbook.

(d) If a camp officer becomes seriously ill, either he or his assistant should at once inform the group officer, in addition to the reports sent in (b), and the group officer will see to the carrying on of the work until instructions are received from the Director.

(e) The group officer reports all cases of sickness to the Director.

(f) If the group officer becomes sick, he should use his discretion in calling in a camp officer to carry on his work.

(g) All officers of the Southern Nigeria Survey are strictly forbidden to do any work on the day after an ordinary attack of fever, and should take two or three days' rest, according to the severity of the attack.

67. (a) *Overlaps of Maps.*—All villages, or permanent objects outside the boundary of a topographical survey and within a reasonable distance, are to be fixed so as to secure a good junction with neighbouring maps. When the boundary of a survey is a river both banks must be surveyed, unless instructions to the contrary are received, in which case only the

Overlaps.

position of certain permanent objects on the far bank need be fixed.

(b) When a political boundary, such as that of a district, forms the limit of the area to be undertaken, the camp officer should survey a certain overlap, according to the scale of the map. This overlap is necessary to ensure a good junction with adjoining maps.

The overlap for the above maps should be as follows:—

For 1 : 125,000 and smaller scales . . .	$\frac{1}{4}$ inch.
Above 1 : 125,000 up to 1 : 31,250 . . .	$\frac{1}{2}$ „
For larger scales than 1 : 31,250 . . .	1 „

(c) *Overlaps of Field Sheets.*—When a graticule forms the boundary of the area under survey, as it usually does in plane-table country, an overlap must be surveyed to ensure a good junction with the adjoining field sheets.

This overlap for graticules should be as follows:—

$\frac{1}{4}$ inch for 1 : 125,000.
$\frac{1}{4}$ inch to $\frac{1}{2}$ inch for 1 : 62,500.
$\frac{1}{2}$ inch to 1 inch for 1 : 31,250.

These field-sheet overlaps should not be included in the area of the camp officer's turn-out, but may be given separately in his annual report.

(d) Where a piece of framework forms the boundary of the area under survey, as is usual in forest country, no overlap need be surveyed.

(e) Overlaps are often of great value in adjusting marginal discrepancies, which are dealt with in para. 73 (i).

(f) When field camps are working in pairs in plane-table country, cases will occasionally occur when camp officers can collaborate in reducing the minimum overlaps, thus expediting the work, but great care must be exercised not to overdo such reduction. In certain cases, however, a camp officer may have to trespass on his neighbour's area for some miles, as, for example, in joining a compass traverse to some fixed point on the main framework lying on the next field sheet. Camp officers will always keep each other well advised of their actions in this respect to save duplication of work.

68. (a) The Rules adopted by the Royal Geographical Society in 1878, and approved by the Colonial and War Offices, will be observed in spelling all names.

Spelling of Place Names.

(b) *Exceptions.*—The spelling of those names which have from historical association or long usage become familiar will not be altered, but the correct spelling will be placed in brackets. These names will be those approved by the Colonial Government, and published in survey circulars from time to time.

(c) *Responsibility for Correct Spelling.*—The Director is entirely responsible to the Government for the spelling of all names except those in (b), but should always take advantage of the local knowledge of experienced persons (Annual Report of Colonial Survey Committee, 1908-09.)

As it is manifestly impossible for the Director to visit every place surveyed, all members of the Survey are held responsible for spelling

as correctly as possible, and in accordance with the rules given in this paragraph, the name of every place that falls within their area of work.

(d) *Correction.*—At the end of the season the names are submitted to the Director, as detailed in para. 76 (b).

Rules.

(e) The following extracts from, and additions to, the Royal Geographical Society's Rules will be found sufficient to meet all cases.

Rule I.—The true sound of the word as locally pronounced will be taken as the basis of the spelling.

Rule II.—An approximation, however, to the sound is alone aimed at. A system which would attempt to represent the more delicate inflexions of sound and accent would be so complicated as only to defeat itself. Those who desire a more accurate pronunciation of the written name must learn it on the spot by a study of local accent and peculiarities.

Rule III.—The vowels are pronounced as in Italian, and consonants as in English.

Rule IV.—Every letter is pronounced, and no redundant letters are introduced. When two vowels come together, each one is sounded, though the result, when spoken quickly, is sometimes scarcely to be distinguished from a single sound, as in *ai*, *au*, *ei*.

Rule V.—In the case of names of places lying in the French or German colonies bordering Southern Nigeria the spelling adopted by those powers is retained, but the correct spelling is placed in brackets under or after the name, as in (b).

Rule VI.—The Royal Geographical Society's Rules lay down that local generic geographical terms, *i.e.*, those for rivers, mountains, etc., should be retained as a rule. In Southern Nigeria, however, this would only lead to confusion, owing to the variety of languages spoken.

River or Stream will be shown by the letter R or S following the name. When a surveyor asks the name of a river he is often told it is "Odo" or "Omi," but neither of these words is the name of the river, being Yoruba for "river" and "water" respectively.

Mountains and Hills.—The words "mountains" or "hills" should be placed after the name of ranges as a rule, but in the case of single peaks and hills the word "Oke," signifying hill, should be placed before the name. "Okuta," signifying rock, should not be given as a name to a rocky hill. The word "Oke" is occasionally used in conjunction with another word in the name of a village although no hill may exist locally. It probably signifies that the man who built the village was born on a mountain, or something to that effect.

Villages, etc.—The word "village" is not entered after the name, but the letters "Vil" should be placed by the symbol when the name is unobtainable. Surveyors should guard against giving "Abule" as the name of a village, as it is Yoruba for "village."

Market-places.—The Yoruba word "Oja" (pronounced *Awja*) signifies "market," and should not be used as a name, for in Yoruba country the majority of market-places possess a name though no one may be living there.

In the Ibo country of the Central and Eastern Provinces market-places are called "Ekke," "Nkwor," "Orio," and "Afor," according to the day of the week on which they are held. (There are four days in the Ibo week.) These names may be given to the market-places either singly or, what is more usual, in conjunction with the name of the tribal locality in which they lie. As, for example, "Orio-Amasere" signifies "a market-place of the Amasere locality held on the third day of the week."

Rule VII.—Spelling in the Field Book.—The surveyor must carefully get as exact a pronunciation as possible from more than one native, taking care that he is a native of those parts and not a stranger. He should examine natives separately and not together. He should then, if an educated native is available, ascertain the meaning of the name, as this is a great help in the ultimate correction of the spelling by the Director, and write it in his book.

He must not be influenced by the spelling given in any guide map issued before June 1911.

He must then *print* the name in capital letters, *as it is pronounced*, in brackets, using any system he likes as long as it gives the English equivalent to the pronunciation. On the left of the brackets he then writes the name by applying the rules of spelling given in Rule IX.

For Example.—For the village "Shangobiyi" he writes in brackets (SHAN-GO-BEE-YEE), then gives the correct spelling Shangobiyi on the left, and under it writes "The God of Thunder (Shango) has brought forth this child."

Rule VIII. Diacritical Marks.—These were at one time used on the maps of Nigeria but have been abolished. They are extensively used in Yoruba, and a knowledge of the diacritical mark used under the letters *e*, *o*, and *s* is essential to enable the surveyor to spell the name correctly from the field book entries of his native assistants.

ẹ is pronounced short, as in the English word "bet." For example, a Yoruba would spell Ekkerrin as Ẹkerin.

ọ is pronounced *aw*, as in the English word "saw." For example, Ọba should be spelt Awba.

ṣ is pronounced *sh*, as in the English word "shall." For example, Ṣaki should be spelt Shaki.

Rule IX.—

Letters.	*Pronunciation.*	*Examples.* (*The words in brackets to be pronounced like the English words.*)
a	*ah*, as the *a* in *father*.	ATAPA (Ah-tah-pah).
a	*a*, as the *a* in *tap*, if followed by a double consonant.	ATAPPA (Ah-tap-ah).
e	*eh*, as the *a* in *mate*, or as the first *e* in the French word *fête*.	AKIYEYE (Ah-key-yea-yea).
e	Short, as the *e* in *bet*, if followed by a double consonant.	KELLEBERRI (Kell-a-berry).
i	Like the English letter *e*, or the *i* in *ravine*.	OWIWI (O-wee-wee). IJU (E-jew).
i	Short, like the *i* in *bitter*, if followed by a double consonant.	ABIJJU (Ah-bij-oo).

Letters.	*Pronunciation.*	*Examples.* (*The words in brackets to be pronounced like the English words.*)
o	Like the English letter *o*, as the *o* in *sober*.	AWOWO (Ah-woe-woe). OTON (Oh-tone).
o	Short, like the *o* in *hot*, if followed by a double consonant.	OTTA ('Ot-tah).
u	*oo*, like the *oo* in *boot*.	IBU (E-boo).
u	Short, like the *u* in *mud*, if followed by a double consonant.	EBUNNI (A-bunny).
ai	Like the English letter *i*, as *ai* in *aisle*.	AJAIYE (Ah-ji-yea).
au	*ow* in *how*.	BAUCHI (Bough-chee).
aw	If followed by a consonant or at the end of a word, like *aw* in *law*.	AWBA (Awe-ba). AWWAH (Awe-wawe).
	Otherwise the *a* is pronounced *ah*, as in the examples.	KAWO (Kahwoe). AWI (Ah-wee).
ei	Pronounced separately, as the English letters *a* and *e*. Scarcely distinguishable from the *ei* in *eight*, or the *ey* in *they*.	OJEI (Oh-jay-e).
c	Always soft, but is practically never used, as *s* is usually sufficient.	
ch	Always soft.	
ph	Never pronounced *f*, but as the *ph* in *loophole*.	SOPHO (Soap-ho).
y	Never used as a terminal.	

Village and River Reference Tables.

69. (a) No names of villages or rivers are to be printed on the field sheet to avoid obscuring the detail. A marginal reference table for villages and another for rivers is kept in the border. On the field sheet each village is given a black reference number surrounded by a black square, and this number, together with the name of the village, is placed in the Village Reference Table.

(b) In the case of rivers, the reference numbers are in blue, surrounded by a blue square.

(c) Remarks on reference Nos. are given in para. 71 (e) and (f).

(d) On the completion of a field sheet, the reference tables are treated as in para. 76 (b).

Field Books.

70. (a) The field books used by the Southern Nigeria Survey are of ten classes, as follows:—

I. *Field Note-book.*—Use given in para. 63.

II. *Reference Book.*—Use given in para. 63 (e).

III. *Village Field Book.*—Issued prepared in tabular form. Uses given in para. 71.

IV. *River Field Book.*—Issued prepared in tabular form. Uses given in para. 72.

V. *Compass Traverse Field Book.* (*See* para. 117.)

VI. and VII. *Theodolite Traverse Angle and Chain Books.* (Paras. 168, 169, and 171.)

VIII. *Trigonometrical and Astronomical Field Books.*

These are combined in the Angle Book used by the School of Military Engineering, Chatham.

IX. *Barometer Field Book.*

X. *Base Measurement Field Book.*

(b) All field books are issued with slips pasted outside the cover in the form given below, in addition to which all field books will have slips containing instructions for upkeep according to their class.

.....(x).....Book. No.....
Surveyor's Name.....
Field Camp No.....
Field Sheet No.....
Field Season.....

In the space marked (x) the surveyor will write the class of field book, such as "Field Note," "River Field," etc.

(c) All the pages of field books will be numbered.

(d) When a field book is full and a new one started reference will be made in the contents column to the new and old books respectively.

(e) The first two pages of every field book will be kept for a summary of the contents.

(f) Field books will be numbered with a catalogue number. At the beginning of the season group officers will obtain sufficient numbers from the Chief Draftsman to cover their work, and will issue these numbers to the camp officers so that no re-numbering will be necessary. The books of each class will not be kept separate.

(g) The Field Book Catalogue will be kept in six columns: Catalogue number, number given by the field camp (if necessary), number of the field camp, field season, contents, remarks.

(h) No field book will be allowed to be taken out of the office without the special sanction of the Director, and a receipt must be given to the Chief Draftsman.

71. (a) This book will be used for recording all information concerning villages, and information collected thereat concerning roads, stations, and other information such as local products, etc.

Village Field Book.

(b) At the beginning of the field book is a slip printed as follows:—

In entering the information required under the following thirteen headings, surveyors need not write the full heading, the Roman number of each being sufficient.

I. Reference No.....on Field Sheet No..... (*See* para. 69).

II. *Name.*—This must be spelt as correctly as possible in accordance with the rules of spelling (para. 68). The phonetic pronunciation in the surveyor's own spelling to be entered in brackets, the syllable accented being underlined and accents used. If an educated

native is available, he should be asked to write the name himself in the field book. Names must be *printed* not *written*.

III. Number of (a) compounds, (b) huts, and (c) well built houses, the number of each being given.

IV. Write down if there is a church (give denomination); temple; European court; Native court; Commissioner's quarters; Government quarters, such as medical officers, hospital, customs, police, or military; European or Native traders (give nationality and nature of trade); or rest house. State if there is a market and the number of days' interval at which it is held.

V. (a) *Name of Head Chief, Chief, or Bale of Village.* (b) The tribe to which he belongs. (c) Head Chief to whom he owes allegiance. (d) The Commissioner to whom he goes for justice.

VI. *Population.* (Number of carriers available in brackets.)

VII. *Water Supply* and where, giving nature and referring if necessary to reference number in River Field Book.

VIII. *The Sanitary State* of the village from the point of view of its healthy or unhealthy surroundings, and its desirability as a camp for Europeans.

IX. *Any Camping Ground* near or at the village suitable for troops, stating roughly the space available.

X. General information as to character and destination of roads leading from the village, or from the main road between that village and the next; names of rivers that cross the roads near the village, etc.

XI. Any information concerning local rubber, cocoa, and cotton agriculture, etc.; local mining camps or concessions.

XII. Any information concerning the *tribal boundaries.*

XIII. If near or on a river, the number of canoes available.

(c) A reliable sketch, *see* 117 (l), must always be made on an auxiliary sheet of the more important towns. The ordinary auxiliary sheet in use at the moment may be used if the scale is sufficiently large. Also *see* 74 (n).

On this auxiliary sheet much of the information asked for in items IV., VII., IX., and X. can be shown. The position of any trigonometrical, plane-table, or traverse stations will be shown, and a north point and scale inserted.

(d) In the case of small villages, the names of which will be omitted on the 1:250,000 and 1:500,000 maps eventually compiled from the standard map, it should be stated whether there is any important reason for not omitting them.

(e) When more than one surveyor is working on a field sheet, the camp officer will either allot certain distinguishing numbers to each, or will instruct them merely to pencil their numbers, afterwards renumbering the villages in ink both in the Village Field Book and on the auxiliary sheet.

(f) A separate village field book must be used for each field sheet. In the case of villages in the overlap, this will lead to each village having two numbers, one on each field sheet. A note must be made in the Village Field Book to that effect.

(g) In the case of small villages much of the information can be omitted, the most important items being I., II., III., V., VI., VII., and XII.

72. (a) This book will be used for recording all information concerning rivers, streams, creeks, lakes, sea coast, etc.

River Field Book.

(b) At the beginning of the book is a slip printed as follows:—

In entering the information required under the following headings, the surveyor need not write the full heading, the Roman number of each being sufficient.

I. Reference No.....on Field Sheet No.....

II. Name (spelt as in para. 71, II.).

III. Width of water during floods (and in dry season in brackets).

IV. Depth of water during floods (and in dry season in brackets).

V. Width of water at time.

VI. Depth of water at time.

VII. Nature of banks.

VIII. Nature of bed.

IX. Nature of water (whether good for drinking, strong flow, sluggish, or stagnant, if dry during dry season).

X. In the case of large rivers, the existence of fords and ferries must be ascertained by inquiry and entered, for in surveying it is possible to pass these without noticing them.

XI. The name of the river or creek into which it flows.

XII. The names of any tributaries, and whether up or down stream of the place the surveyor is at.

XIII. The names of any towns or villages on the river, if ascertainable from the local natives, will be very useful in assisting the surveyor to identify the river when he again meets it on another road.

(c) When a river is being surveyed, the information under items III., IV., V., VI., VII., and VIII. need not be entered in the River Field Book, but only on the auxiliary sheet. If an auxiliary sheet is not kept, the reference number used for the river must be repeated on the field sheet at those places along its length where it may change its nature, the number being followed by the letters a, b, c, etc., and fresh entries made in the River Field Book.

(d) Remarks similar to those in para. 71 (e) and (f) apply also to river field books.

73. (a) The systematic checking and testing of field sheets is the duty of the group officer.

Checking Field Sheets and Work.

(b) It is impossible, however, for the group officer himself to check the work of all his field camps, so, on the principle of every camp officer being responsible for his own field sheet or block, the work of the native surveyors will be checked by the camp officers, while the work of the latter only is tested by the group officer. The group officer should, however, test as much of the native surveyors' work as his other work permits.

(c) The group officers will visit the camp officers and their assistants *while at work*, noting their methods, pointing out how their work can be improved, and generally advising and instructing them.

(d) The methods by which the systematic checking of the field sheets can be carried out are various, depending chiefly on the nature of the country, and are left to the discretion of the group officer.

(e) "*Perambulator Partal.*—In open country, tolerably flat and unenclosed, a check-line measured with a perambulator is as rapid and accurate a method as any. The plane table should be set up somewhere near the edge of the ground to be tested, and the position carefully fixed by the surrounding trigonometrical points. The perambulator may then be started off in a bee line through the work, its readings being recorded where the line passes any features on the ground until it is desirable to change the direction. The plane table is then set up again, the distances of the features noted along the line are compared with work thereon, and then, a new line being chosen, the process is repeated as often as necessary. Rays should be taken to neighbouring villages, hills, streams, etc., whenever the table is set up."—(S.I.)

(f) "*In situ Fixings.*—In hilly country the use of the perambulator is impossible, and chaining is too slow except for small areas. The examiner must then content himself with numerous fixings, testing the topography by rays, and noting whether the sketching adequately represents the ground, and by checking the clinometer heights and contour lines obtained thereby."—(S.I.)

(g) "*Chain Partal.*—The best way of testing a field sheet in open country is to set up the plane table on some prominent point, A. Select a conspicuous object, B, such as a tree, some distance off, and start your chainmen in the direction of B, your assistant noting the cuttings of roads, streams, etc., along A B. Whilst the men are chaining from A to B, you proceed by a circuitous route to B, setting up your plane table at suitable intermediate positions, a, b, c, d, etc., and check the topography on the way. On arrival at B, the assistant reads out the distances along A B where topographical details were encountered, which you then check on the plane table."—(S.I.)

(h) *In Forest Country* field sheets can either be tested by cutting a rope partal through the bush, intersecting several of the surveyed roads and streams shown on the field sheet, or by re-surveying a piece of work here and there.

(i) One of the chief tests, however, is comparison of the edges of adjoining field sheets, and this applies to both open and forest countries. When camp officers meet, they must check the edges of their field sheets, and rectify small discrepancies, *the necessary alterations being made in red and none of the original work erased.* Serious discrepancies should in most cases be rectified by an immediate re-survey after consultation between the camp officers, but if both feel that their work is correct the matter should be reported to the group officer, who will decide on the action to be taken.

(j) No field sheet should be considered complete until it has been tested by the group officer on one or more of the systems described. A field sheet should not be considered as checked by *in situ* fixings alone where it is possible to check by means of a perambulator or chain partal. A chain partal is the best test of the accuracy of detail and is seldom impossible.—(*Adapted from* S.I.)

(k) Supplementary topographical surveys, where previous surveys are transferred in blue to a plane-table sheet and the detail examined

and corrected in the field, generally require more rigorous testing than original work, for there is always the temptation for an unreliable surveyor to accept and ink up the old work without checking it, and thus obtain credit for a large turn out.—(*Adapted from* S.I.)

(l) Remarks on the examination of field sheets in the field should be recorded on them in red ink and signed and dated by the group officer, as it is of much importance to place this permanently on record.

(m) The group officer must sign the record slip on completion of his test (*see* para. 62).

Details and Drawing of Field Sheets.

74. (a) *Symbols.*—All symbols should be shown strictly in accordance with the Plate of Conventional Signs for Field Sheets, which is founded on that used by the War Office in the compilation of the Map of Africa.

(b) *Draftsmanship.*—The quality of different surveyors' draftsmanship unfortunately varies considerably. Those surveyors who do not possess very great gifts in this respect should make every effort to be *as neat and clean* as possible, while those who are gifted with artistic skill are *cautioned against over-elaboration.* In a tropical country where rain and damp are both against good draftsmanship, great care should be taken to keep the paper clean and dry. A piece of tracing linen, glazed side uppermost, should be kept pinned over those parts of the field sheet not in use at the moment, the pins being placed *under* the board. Another piece should be used to keep the, naturally in such a climate, damp hand of the draftsman off the paper.

(c) *Inking In.*—All field sheets must be inked in with Indian ink and colour daily. In forest country the traverses forming the compass framework should be inked in as soon as adjusted, but care must be taken not to run the risk of obscuring future detail by inking in at once the detail of the traverses, the reference numbers, etc. These should be left in pencil until the completion of the block adjoining the framework.

(d) *Limit to Precision of Detail.*—Creeks and streams less than a ¼ mile in length are too small to be shown on the field sheet, and should be omitted unless leading to an important village, landing-place, etc. Their positions should be indicated on the auxiliary sheet.

Surveyors are apt to survey broken ground in far too great detail. Ravines, irregular blocks of rock on hillsides, small ill-defined spurs, etc., often assume magnified proportions in the field, but, if an attempt were made to plot them accurately on the standard field-sheet scale, the details would often be found to be so small as either to be unplottable or to confuse the map. Such details can be sufficiently well sketched by eye and placed on the auxiliary sheet, if one is being used, but on the field sheet it is usually sufficient to show the prominent features and general trend of the ground.

(e) *Approximate and Unsurveyed Details.*—Broken lines are used to show roads, streams, etc., that have been only approximately surveyed. They are also used for roads, etc., that have not been surveyed, but in these cases they are marked (?), *see* (f).

Strict adherence to this Rule is of the utmost importance. The S.I. lays down that "It is very necessary to pay attention to this rule, otherwise the surveyor may very possibly be blamed for bringing in incorrect work in country which he does not profess to have accurately surveyed, but merely sketched in roughly, and moreover users of the map might be misled if no clue existed as to what professed to be accurate, and what merely approximate, in the detail shown."

Unsurveyed Details are those put in from hearsay information only.

Approximate Details include surveys by persons outside the Department, *see* (g); time traverses; rope traverses ending in the air; sound and pace traverses ending in the air; and rivers fixed as in para. 79 (e).

(f) *Use of the Query Symbol.*—The query symbol (?) must be freely used on all unsurveyed details. (*See* Conventional Sign Plate, Sign 59.)

It should be placed on the map so as to be bisected by any road or river to which it refers.

When the name of a village or spelling of that name is doubtful, it must be placed after the name; but if it is the *position* of the village that is doubtful, then the query must be placed on the right-hand side of the symbol denoting the village.

The query symbol must be placed on the right-hand side of all villages, stream crossings, road junctions, etc., fixed by time traverses, but not necessarily at those fixed by other approximate surveys.

The primary object of the query symbol is to avoid misleading the user of the map.

(g) *Sketches and Plans made by Persons not in the Department* will be treated as unsurveyed or approximately surveyed, according to their merits and source. If a camp officer finds them of sufficient value, he should obtain the sanction of the group officer to show them as "surveyed."

(h) *Names.*—These are dealt with in para. 69.

(i) *Hill Features.*—These are dealt with in para. 75, which fully describes the use of figures, spot levels, etc.

Symbol 12 applies to form-lines surveyed by plane table in open country, certain points on them being fixed and the remainder put in by eye.

Symbol 13 applies to form-lines which have only been fixed where they cross surveyed roads and rivers, and by partals. In fact, "broken" form-lines are practically those in forest and scrub country.

Symbol 14 is only used when the form-lines have not been surveyed at all, and show hills that are put on the map from hearsay or from a distant view. They are very rarely used.

(j) *Forests, etc.*—It is impossible to draw a hard and fast line between different types of country, such as between forest belt and scrub, forest and park-like country, etc., and also to differentiate between the various types of forest and scrub. Accepting the fact that absolute accuracy in showing these details is not possible, considering the scale and nature of survey, an attempt can at any rate be made to show the general nature of the country by an intelligent use of Symbols 60 to 63 on the Conventional Sign Plate.

The following remarks are given as a guide to surveyors :—

Symbol 60. Thick Forest of Big Trees and Heavy Undergrowth.—To be shown by a medium green wash.

Symbol 61. Heavy Scrub with Scattered Big Trees.—To be shown by a light green wash. Many typical examples of this country exist between Abeokuta and Lagos. The heavy scrub consists of young trees and undergrowth up to 60 feet in height, with here and there a few great trees, either gathered in clumps or in isolation.

Symbol 62. Park Country.—This symbol must be held to apply to some of the rolling country north-west of Abeokuta, although there it is difficult to differentiate between park country and scrub. Generally speaking, park country consists of grass plains, with or without clumps of bushes, but dotted here and there with clumps and groves of trees. It is generally practicable to walk through, although difficult before the grass is burned. Typical examples of it are in the Onitsha and Udi country.

Symbol 63. Scrub with few, if any, Big Trees.—A common error is to omit to print the word scrub, and put the symbols too close together. This country is common around Lagos, and for several miles up the railway ; also along the coast-line.

(k) *Agriculture.*—The drawback to showing agricultural lands in any detail is chiefly due to the fact that, besides being generally in such small blocks as to be unplottable on the field-sheet scale, they are constantly shifting. What may be a farm one year is scrub for the next five or six, gradually increasing in height and density. The surveyor can therefore show only the general nature of the cultivation on his field sheets in accordance with the hints given below, any large plantation of a permanent nature (such as cotton, rubber, cocoa, etc.) being shown in detail.

Conventional Signs 64 to 76 show various types of cultivation both by symbols and numbers. On the auxiliary sheets the approximate edges of the cultivation are shown by dotted green lines hatched in green on the farm side, and the nature of the crop indicated by a green number.

On the field sheet small green numbers only are used, placed on the approximate position of the farm. Where farms are very crowded it is impossible to place a number for each. A fair approximation is aimed at with a view to giving the general nature of crop.

(l) *Trees and Farms in Forest and Scrub.*—Symbols are also shown opposite Signs 64 (a) to 69. These symbols are scattered over the areas where the trees they represent exist in the forest and scrub country. The commonest use for these symbols is in the forests where rubber trees and vines are indigenous, and in the scrub country south of Abeokuta where numerous oil palms form an oil-palm belt extending east and west for many miles.

A certain difficulty arises in showing farms, which occur in great numbers in the scrub country and to a lesser degree in the forests. The difficulty is met by placing the "number" of the crop approximately where the farm occurs. It is impossible, and also unpractical, to show a clearing in the green wash wherever a farm occurs.

(m) *Buildings.*—Symbols 24 to 35 represent the various types of buildings likely to be met with in Southern Nigeria. Many of these are rare, but others occur in such large numbers in some of the towns

that it is advisable to omit the less permanent on the field sheets. The chief's house in small villages need not be shown.

(n) *Towns and Villages.*—These are fully dealt with in para. 117 (l). Accurate detail cannot be expected on the field-sheet scale, and the device has been adopted of showing one small black block for every fifty inhabitants. This, however, is merely a rough rule to give a general idea of the congested nature of the town area. It is suitable in the case of towns like Ibadan, Abeokuta, etc., in the Western Province, but difficult to apply to Central and Eastern Province towns, many of which are scattered over several square miles of country and divided by belts and patches of forest and scrub into what are practically numerous small villages, all known, however, by the same name. In these cases the method adopted is to show the town boundary by a red line, the market-place (which is usually the most important point in the town), the chief's house, and more important clumps of buildings.

(o) *Roads.*—These are shown by Symbol 57 (a) to (g).

In many cases it is extremely difficult to differentiate between the various classes of roads, especially between bicycle paths and footpaths, where the distinction depends on the amount of clearing and rooting done by the inhabitants of the villages along its length, and which divide it into sections of varying degrees of goodness.

Surveyors are inclined to show too many tracks as footpaths. So long as it is *generally suitable* for a bicycle it should be shown as a bicycle path.

The following rough rules are given as a guide :—

Symbol 57 (a). Main or First-class Road.—Shown by double continuous black lines ; coloured brown. They are under the road department, graded and bridged, and have an average width of 18 feet. When metalled, "met" is printed at intervals along the road. They are suitable for motor traffic.

Symbol 57 (b). Waggon or Second-class Road.—Shown by double black lines, one continuous, the other broken ; coloured brown. They are bridged and sometimes graded, and have an average width of 15 feet. When metalled, "met" is printed along them at intervals. They are suitable for light waggons.

Symbol 57 (c). Third-class Roads or Hand-Cart Tracks.—Shown by double black broken lines. They are from 8 to 12 feet wide, are occasionally graded, and have light native bridges of varying degrees of strength. They are suitable for hand-carts, and generally for motor bicycles. Once known as "double hammock roads."

Symbol 57 (d). Bicycle Paths.—Shown by a continuous black line. The footway is seldom more than 18 inches to 2 feet in width, but is usually well rooted. There may be occasional native bridges, but in the months of August to November ferries are usually necessary. They are *generally suitable* for bicycles and single hammocks, and always for carriers. Not recommended for motor bicycles.

Symbol 57 (e). Footpaths.—Shown by a "short broken" black line. Generally suitable for carriers, but not recommended for bicycles, as they are often not rooted.

Symbol 57 (f). Hunter's Trails, Farm Paths, etc.—Shown by a dotted black line. These are not suitable for carriers.

Symbol 57 (g). Unsurveyed Tracks.—Dealt with in (e) and (f).

(p) *Boundary Posts, Beacons, etc. Symbols 4 to 9, and 15 to 17.*—The right-hand side of these symbols must be reserved for the height, which should always be given on the auxiliary sheet, and usually on the field sheet. Where reference numbers are necessary they should be given in red on the left of the sign. The distinguishing numbers of beacons should not be entered on the field sheet, only on the auxiliary sheet.

(q) *Rivers.*—Care must be taken to show unsurveyed rivers by broken lines. The only exception to this is in the case of streams fixed, as in para. 79 (f).

Hill Features, Vertical Intervals and Form-lines.

75. (a) A brief description of the method by which the hill features of the country are surveyed is given in para. 9, and full details of aneroid, instrumental, and plane-table contouring are given in paras. 116, 130, and 212 respectively. Remarks on the use of the symbols given in the Conventional Sign Sheet in plotting form-lines on the field sheet are given in para. 74 (i.)

(b) *A form-line is distinct from a contour* in that the former is surveyed by fixing certain points on it accurately and filling in the remainder of the form-line by eye, whereas a contour is accurately surveyed along its entire length. A form-line is spoken of as an "approximate contour."

(c) *Vertical Intervals* are fixed by the rule that the vertical interval (in feet) equals 50 divided by the number of inches to the mile (approximately) in the scale of the map.

(d) *On the Standard Map* hills will be shown by form-lines at 100 feet vertical interval. These form-lines will be drawn as continuous brown lines where they have been approximately surveyed. This is practically only in open country. In forest country the expense of clearing renders it impossible to follow the form-lines after they leave the roads, or other cleared spaces, and they should then be shown by broken lines of brown. In the very dense forest, mangrove, and scrub belts, practically none but broken form-lines exist on the map, and the only dependable heights are where they cross surveyed lines, roads, streams, etc.

(e) *Fixing Form-lines in Forest and Scrub Country.*—Surveyors must make every effort to utilise farms, farm tracks, and hunters' tracks for determining by rope traverses and aneroid the position of form-lines. Unimportant as are these details in themselves, they are of the greatest importance in determining the hill features. When a farm about 200 yards wide lies alongside the track under survey in hilly country it is not necessary to survey it in detail. Some conspicuous tree, or a man with a banderole, can be intersected from the road and the aneroid read at the tree or banderole.

Where there are no farm tracks, etc., that can be used for fixing form-lines, use should be made of rope-partals and semi-partals as described in para. 101, IV.

(f) *On the Field Sheets* the rules for the standard map will be followed as given above, but the vertical interval alters with the scale as follows:—

1:62,500 V.I. = 50′ with dotted 25′ form-lines interpolated.

1:31,250 V.I. = 25′.

(g) *In Large Scale Maps,* specially required, the vertical interval will be as follows :—

1 : 12,500 V.I. = 10′.
1 : 5,000 V.I. = 5′.

(h) *In the Supplementary Topographical Survey of Concessions* the vertical interval is according to scale as in (f) and (g).

(i) *Height Figures.*—Surveyors should pay particular attention to the fact that all heights of points and contours based on aneroid readings are shown by sloping brown figures ; and those based on triangulation, plane-table work with telescope alidade, and instrumental levels by upright brown figures. The difference should on the field sheet be accentuated by making the upright figures lean slightly to the left.

(j) *Accentuating Form-lines.*—On the 62,500 and all smaller scales, the 500′, 1000′, etc., form-lines will be slightly thicker than the others.

(k) In field camps on plane-table work with inexperienced native surveyors it is better to entrust them with only the outlines of the detail survey, omitting the form-lines. The camp officer subsequently inserts the form-lines on the field sheet, thus ensuring the double object of accurate contouring and a thorough examination of the sheet in the field, advantages which are cheaply gained at the sacrifice only of the small extra time required to go twice over the same ground.—(*Practice adopted by* S.I.)

(l) *Spot Levels.*—The number of these that should be shown on the field sheet is left to the surveyor's discretion. In open country they should always be given on the right of trigonometrical points, and are also useful in marking small knolls lying between the form-lines.

In all types of country they should generally be shown on the roads where the latter cross streams, hill-tops and valleys, and at cross roads, provided that the form-lines are so far apart, owing to the ground being ill-defined, as to render this necessary.

It is usual only to include primary and secondary heights among the spot levels shown on the field sheet, but tertiary heights at the end of semi-partals, and occasionally on partals, are very useful.

All levels determined should be shown on the auxiliary sheets.

76. On return to Headquarters, and before finally handing in the field sheets to the Director, the following details must be attended to in finishing them. As these sheets may require completion on the voyage home attention is directed to para. 57, IX.

Completion of Field Sheets.

(a) In completing their field sheets camp officers must act on the principle that the sheets should be clearly understandable not only to them, but to the publisher and to all who may have cause to refer to them in future years.

(b) The spelling of names in the reference tables must, after comparison with the village field books and correction by the Director, be altered in red where necessary, and the style of printing for the names indicated by the red numbers 1 to 5 corresponding to conventional signs 37 to 41 respectively, and 6 to 8 corresponding to 45 to 47.

(c) Intersected points with single values, *i.e.*, those fixed by two rays only, which are found wrong, should be crossed out in red on the field sheets and in the reference table in the field note-book, *the fact being reported to the Assistant Director, Trigonometrical Section.*

(d) The camp officer is responsible for seeing that all the edges of his field sheet bear the group officer's initials in red as evidence that they have been checked with adjoining sheets.

(e) *Checking Symbols.*—Every detail plotted on the field sheet should be checked with the Conventional Sign Plate to see that the correct symbols have been used. Where special symbols are necessary the Director's approval must be obtained.

(f) "*Border.*—A border must be drawn round the bounding graticule as shown in the Conventional Sign Plate, the figures for the latitudes and longitudes to be carefully hand printed or typed. The border may be broken to avoid interfering with the marginal reference tables or with the detail of the overlap. It should include the whole area, even if only a portion has been surveyed."—(S.I.)

(g) The places from, or to, which the roads lead when they cross the border must be hand printed outside the border. The word "from" to be entered when the town or village from which the road comes lies west of the centre meridian of the field sheet, and the word "to" when it lies east of the centre line.

(h) *The Heading, Magnetic Variation, etc*, must be carefully completed in accordance with the Conventional Sign Plate.

(i) *The Field Sheet is not to be taken off the Board unless ordered*, and then is never to be detached from the cloth on which it has been mounted. When taken off the board the sheet edges must at once be bound with ribbon.

(j) *Signature.*—The officer responsible for the production of a field sheet will, on its completion, sign his name in the margin. Such signature acts as a certificate from the officer that the survey shown on the sheet faithfully represents the topography of the country.

Military Surveys.

77. "Special surveys of limited areas on the scale of 1 : 31,250 are sometimes required by the Military Department for tactical purposes in the manœuvring of troops. The only difference between these surveys and an ordinary topographical survey is that form-lines have to be inserted with greater care, especially in undulating ground, where also a much larger number of alidade and relative heights must be scattered about in places of military importance. The positions and heights of all conspicuous objects, such as isolated trees, mounds, rocks, houses, temples, wells, etc., should be carefully fixed for the purpose of range finding. Bridges, culverts, embankments and cuttings on railways, must be shown, and all roads and footpaths carefully classified. The depth of the surface of the water, as well as the depth of the water in wells, should also be recorded.

"Surveys of a similar nature are sometimes required of military defensive positions on the scale of 1 : 12,500 and larger. In such surveys still greater accuracy is required, and the contour lines should be at a maximum vertical interval of 10 feet apart, whilst

every 25-feet contour on undulating ground must be carefully measured with a level."—(S.I., *altered slightly.*)

Re-Magnetizing Compass Needles.

78. "A good trough compass that is fairly sensitive and plays freely is a great aid to rapid plane-tabling, in as much as it usually enables the surveyor to set his plane table so correctly that the intersections of the rays to the surrounding points give him at once his true positions without the necessity of a second approximation. In order to magnetize needles when a pair of magnetic bars is available for the purpose, draw the southern pole of one bar along the northern pole of the needle from the centre outwards, taking care to keep the bar moving continuously in one direction—that is, the bar should not be rubbed backwards and forwards along the needle—and *simultaneously* in a similar manner draw the northern pole of the other bar along the southern pole of the needle. The needle must be held down by a second person whilst this is being done. After giving twelve strokes to one side, the needle should be turned over and the reverse side similarly treated. No needle will work well unless the pin is sharp, the agate bearing dry and clean, and the balance properly adjusted.

"The magnetizing bars when not in use should be so placed as to have the north pole of one towards the south pole of the other, and the armatures attached to them. Needles when not in use should be thrown off their pivots by the lever provided for this purpose; this should always be done whenever it is taken off the plane table. All needles should be tested by camp officers before being served out for use in the field."—(S.I.)

River and Creek Surveys.

79. (a) The survey of rivers and creeks in Southern Nigeria is very difficult owing to the fact that the former usually flow through dense forest, and the latter through heavy mangrove forest with banks so swampy that it is practically impossible to land much less to set up a plane table. The methods of survey depend on the size and importance of the rivers, and are briefly as follows:—

(b) *Large Rivers with Firm Banks in Forest Country.*—Some of these can advantageously be surveyed as part of the framework as described in para. 176. Those that are not utilised to form the framework will have certain points on them fixed where they do cross the framework, the sections of the river between these fixed points being surveyed either at low water during the dry season by plane-table traverses, or by secondary or tertiary compass traverses; or, if the river is not sufficiently low, by compass or plane-table traverse from bank to bank, the legs measured with a floating rope similar to that described in (c).

(c) *Tidal Creeks and Deep Rivers in Forest Country and with Swampy Banks.*—In this case landing on the banks except at rare intervals is practically impossible. Certain fixed points can be obtained where the creek or river crosses the framework and other surveyed roads, but these are often so far apart, owing to the immense area of creek and mangrove country in the neighbourhood of the

Niger delta, that the following system of "*water traverse*" has been devised.

Two canoes are necessary, the surveyor being in *Canoe 1* with his compass and 1000-feet lead-line (with corks at 50-feet intervals) on a reel. The assistant or an intelligent headman is in *Canoe 2*. Starting from the fixed point, *Canoe 1* moors to the bank and pays out the lead-line as *Canoe 2* drops down the stream with the end of the line on board. On reaching a point where the lead-line is fully paid out, or where a curve of the river would shut the canoes out from view of each other, *Canoe 2* moors to the bank after pulling the lead-line taut.

The surveyor takes his bearing and notes the linear measurement. He also takes bearings to any object of detail on the opposite bank so as to fix it by intersection from the next station. He completes his plotting on the auxiliary sheet as his canoe drops down to the position occupied by *Canoe 2*. He notes where tributaries or paths join the river, and blazes trees thereat in the same way as laid down for ordinary compass traverses. *Canoe 1* winds in the lead-line, moors to the place occupied by *Canoe 2*, and the latter drops down stream again.

Caution.—Care must be taken not to strain the lead-line, which must be checked by the standard band immediately before and after work. *The lead-line should be allowed to soak in the water for at least three hours before testing and beginning work.*

A latitude should be observed every 15 to 20 miles at some convenient village on the bank. This is especially useful when the river runs more or less east or west, when the distance apart of observed latitudes can with advantage be reduced to 10 miles.

(d) *Medium-sized Rivers with Firm Banks in Forest Country*, such as the Ogun, Awna, Awshun, etc., should be surveyed at low water either by tertiary or rope traverses between fixed points. It may occasionally be necessary to employ the water traverses described in (c).

(e) *Small Streams in Forest Country.* — Those are usually so overgrown with undergrowth that, though usually dry in the dry season, they are very difficult to get along. Numerous points on them are usually given by the places where compass traverses cross them, and these can be joined up by rope traverses run along the bed of the stream.

There is another and very useful method that should be employed if a path happens to run alongside the river, a rope traverse being run along it and semi-partals being cut to the river at intervals as described in para. 101, IV.

Surveyors must take every care to run numerous semi-partals or short lengths of tertiary traverse from any path they may be surveying to any river or stream that they know is close at hand. If sufficiently done this procedure may preclude the necessity for any further survey of the smaller streams.

(f) *If fixed by road crossings and partals, as described in (e), at points not more than 1 mile apart as the crow flies, the small streams mentioned in this subparagraph may be shown on the field sheets as "surveyed," but not on the auxiliary sheets.*

Note.—Camp officers should remember that streams, however small,

are far more valuable from a topographical point of view for breaking up a block in which no other detail exists than rope partals.

Setting up on Unstable Ground.

80. "In muddy and marshy places a firm footing may sometimes be obtained for theodolites and plane tables by driving in wooden pegs flush with the surface of the ground for each leg to rest on, and in sandy soil a certain amount of stability can be effected by inserting each leg of the stand into a square or circular piece of wood with a hole drilled through its centre to allow it to travel a foot or so up the leg."—(S.I.)

Checking existing Maps, and using Cadastral Plans.

81. (a) Camp officers must see that they are supplied before leaving Headquarters with the latest copy of any topographical map, produced by the Department, of the district in which they are working, or through which they may have to pass.

(b) "They should consider it a duty to make themselves thoroughly conversant with the history and quality of each one of these maps, noting all information on those points in ink on the backs of the maps. They will thus be enabled to point out where new surveys are required, and over which areas a revision or supplementary survey will suffice."—(S.I.)

(c) *Cadastral Plans.*—Camp officers will obtain from the O.C.B. any cadastral plans of lands in the district to which they are going. They will be able to judge on arrival on the ground whether they can utilise these plans with or without supplementary survey.

(d) "Camp officers should take every opportunity when in, or going to or from, the field of roughly examining the work in any of the sheets previously surveyed through which they pass, so as to get as correct an idea as possible of future requirements, and whenever possible should note on the maps any new roads, villages, etc., that may have been made since publication, so that, should a new edition or stock of any sheet be required, the new work may be shown on it without delay."—(S.I.)

(e) An immediate report to Headquarters should be made in all the foregoing cases.

Native Surveyors: Their Duties and Capabilities.

82. (a) The duties of native surveyors in the field are confined to survey work and camp administration. They are on no account to be employed by camp officers on office duties, as clerks, etc., except on exceptional occasions, and then merely as a temporary measure.

The form to be used is given below. In filling it in the camp officer should use:—

V.G. for "Very Good."
G. for "Good."
I. for "Indifferent."
B. for "Bad."

The letter C., signifying "Careless," should be added to any of the above. For example, G.C. signifies "Good but Careless."

Confidential Report on Native Surveyors.

1. Full name.....
2. Country.....
3. Age last birthday.....
4. Where he learned surveying.....

5. *Triangulation*—
   - (a) Advance work.....
   - (b) Observing.....
   - (c) Computations.....

6. *Plane-table Survey*—
   - (a) Surveying without contouring.....
   - (b) Contouring with alidade.....
   - (c) Traverse by back ray.....
   - (d) Traverse by trough compass.....

7. *Theodolite Traverse*—
   - (a) Adjusting instrument.....
   - (b) Observing.....
   - (c) Computations.....

8. *Compass Surveys*—
   - (a) Primary traverses.....
   - (b) Secondary traverses.....
   - (c) Co-ordinates from tables.....
   - (d) Tertiary traverses.....
   - (e) Double chaining.....
   - (f) Single chaining.....
   - (g) Rope traverses.....
   - (h) Sound and pace.....

9. *Keeping Field Book*.....

10. *Levelling*—
    - (a) Topographical levels.....
    - (b) Secondary heights.....
    - (c) Secondary computations.....
    - (d) Aneroid levels.....

11. *Field Astronomy* (in each case state star or sun)—
    - (a) Time observations.....
    - (b) Time computations.....
    - (c) Azimuth observations.....
    - (d) Azimuth computations.....
    - (e) Latitude observations.....
    - (f) Latitude computations.....

12. *Draftsmanship*—
    - (a) Lettering.....
    - (b) Quality of drawing.....
    - (c) Plotting by S.N. protractor.....
    - (d) Plotting by co-ordinates.....

13. *General Knowledge of the Principles of Topographical Survey in Map Making*.....

14. *Camp Administration*—

(a) Control of carriers.....
(b) Keeping carriers' book.....
(c) Keeping cash account.....
(d) Shifting camp.....
(e) Methodical.....

15. *Personal Character*—

(a) Is he truthful?.....
(b) Is he inclined to fake his work?.....
(c) Is he honest?.....
(d) Is he sober?.....
(e) Is he trustworthy?.....
(f) Is he obedient?.....
(g) Is he quick-witted?.....
(h) Is he lazy?.....
(i) Is he keen on his work?.....
(j) Is he cheerful?.....

16. *Has he any Esprit de corps?*.....

17. *Is he entirely Fit to Command*—

(a) A detached camp?.....
(b) A field camp?.....

18. *General Recommendation*. .....

(Signature of camp officer.)

(b) The camp officer must state under Heading 18 if he recommends that for the next field season the native surveyor should be employed as before, reduced a grade or increment (if so, why?), or promoted a grade or increment.

(c) The attention of native surveyors is drawn to the above report as a guide to methods of self-advancement.

Erection of Survey Beacons.

83. (a) Permanent topographical survey marks are of three classes, viz: trigonometrical stations; bench marks cold-chiselled on permanent masonry walls, buildings, flagstones; and survey beacons of approved pattern.

(b) *Trigonometrical Stations* are usually heavy stones or concrete pillars, up to 2 feet high, on the top of which is engraved a circle about 3 inches in diameter with a dot in the centre to mark the exact point. When not in use these stations are covered by a pile of stones 5 feet high and six feet square at the base. When in use a "cockshy," from 10 feet to 30 feet high, is built over the station for the use of plane-tablers.

(c) *Bench Marks.*—When marks are cold-chiselled on objects, such as walls, care must be taken that the objects are permanent. If the

object is a boundary pillar, offsets to some other permanent objects should be taken in case the boundary pillar is removed.

All cold-chiselled marks will consist of a line 3 inches long over an arrow head, both painted red, the centre of the line being used as the bench mark.

(d) *Survey Beacons* are of approved pattern and can be used when there are not sufficient permanent natural or artificial features for marks under (c). They must be sunk with their top surface about 4 inches below the surface of the ground, their position identified by bearings and distances to two natural or artificial objects blazed with arrow heads, and they must be covered with a pile of earth or stones, 3 feet high.

(e) In theodolite traverses forming the framework, survey beacons must be placed in pairs at points not more than 5 miles apart. The points are usually at important cross roads or villages, and a pair of beacons should be left at any point near which the surveyor has reason to believe a concession may be taken up.

The beacons should be at two adjoining traverse stations, and should be set up (so as to avoid the trouble of centering) before the angles at those stations are observed. It will generally be found most convenient to set them up at azimuth stations. The object of placing the beacons in pairs is to preserve the true bearing for the use of compass traversers in determining local magnetic variation.

(f) *Lists of Beacons.*—Camp officers will keep a list in their field note-books of all the survey marks made or erected by them during the season, together with the preserved true bearing, the latter being marked "observed" or "deduced." Also a list of the persons in whose care they are left, *see* (i).

(g) Great care must be taken to place marks in such a position that they are not likely to interfere with traffic or be turned over. Parties working along railway clearings ahead of construction must be careful to see that they are not placed too close to the permanent way, where future cuttings and embankments may entail their removal.

(h) A surveyor working near one of the permanent marks already existing will always tie his survey on to it. In all cases, whether a surveyor is working, or is merely passing by, he will make his carriers clear all vegetation from round the beacons, and will note their state, *see* (j).

(i) All survey maps should be personally shown to the local village *bale*, who should be informed that they are Government marks, that he is responsible for their preservation from injury by his people, and that he must at once inform his Commissioner if they are damaged or destroyed. Certificates to be handed to the *bale* are obtainable at Headquarters. (Survey Form No. 28.)

(j) To ensure preservation, camp officers are to inspect either personally or through their assistants, any survey marks lying in their area, a list of which he will take with him in his field note-book. If repairs are necessary, and are of such a nature that he cannot carry them out locally, he should at once report the matter to Headquarters.

He will enter in his field note-book the date of inspection and condition of each mark, and will furnish a report to Headquarters at the end of the field season.

(k) All surveyors removing the pile of stones over trigonometrical stations or survey beacons to erect an instrument or a "cockshy" are to replace the pile when finally leaving the station.

(l) Surveyors on compass traverse work should always leave either a good bench mark or a survey beacon in every village however small.

(m) *Temporary Marks.*—Cutting bench marks on trees *for use as permanent marks* is forbidden, though trees may be blazed or painted as reference points near a survey beacon. Blazed trees are also very useful as temporary beacons in places where it is not considered necessary to place a survey beacon, and free use of them should be made in the survey of an area. *See* para. 117 (m). In compass traverses in forest country, trees or posts must be blazed with an arrow head, painted red, at every road-junction and stream-crossing.

84. (a) A camp officer will report weekly to his group officer his position and intended movements during the next fortnight. These movements should be adhered to, but, if changed, the group officer should be at once informed. These weekly reports will be sent by the weekly messenger mentioned in para. 88, and will include a statement of progress.

Weekly Reports Due from Group and Camp Officers.

(b) The group officer will report weekly to the Director his position and intended movements during the next fortnight. His weekly report will be sent by the weekly messenger to his field depôt for transmission to Headquarters.

(c) When the Director is in the field the group officer will address his letters to "The Director of Surveys, Headquarter Camp," care of the Director's Field Depôt, the name of which will be notified by survey circular, and will be sent under a separate cover to the person in charge of the group officer's field depôt, asking him to forward it to the Headquarter Camp Field Depôt.

(d) In most cases group officers will find it convenient to send their weekly reports direct to the Headquarter Camp. The Director will, as far as possible, let his group officers know his intended movements.

(e) No requisitions for stores should be sent to the Headquarter Camp, but addressed to "The Chief Assistant, Survey Headquarters, Lagos."

85. At the end of the field season a camp officer will hand in the following returns:—

Returns Due at End of Season.

I. His annual report. (*see* para. 86.)
II. His field sheets (except as in para. 57, IX.).
III. His auxiliary sheets (except as in para. 57, IX.).
IV. His field books (except as in para. 57, IX.).
V. His co-ordinate sheets.
VI. His astronomical observation books.
VII. His astronomical computations.
VIII. His diaries.
IX. His confidential report on assistants. (Para. 82.)

It is a camp officer's duty to see that all field books, sheets, etc., are correctly and clearly completed with their description, number of field camp, field season, and camp officer's name.

86. (a) Annual field camp reports are of two kinds, viz., those furnished by the group and camp officers respectively.

Annual Field Camp Report.

(b) Camp officers will hand in field-camp reports to their group officer before midday of the day before embarkation, except as in para. 57, X., under the following headings:—

I. Field Camp No..... Field Season.....
Name of camp officer.
Names of surveyors and assistant surveyors.
Names of pupil assistants.

II. Date of landing in the Colony.

III. Date of leaving Headquarters.

IV. Date of returning to Headquarters.

V. Date of embarkation for England.

VI. Names of headmen, and capabilities, and if they have been re-engaged. (Hand in certificate given in para. 34.)

VII. Names of chainmen, and capabilities, and if they have been re-engaged. (Hand in certificate given in para. 34.)

VIII. Numbers of field sheets surveyed, and state whether completed or incomplete. If blocks only were surveyed, state which blocks on which field sheet.

IX. Fill in the Annual Report Table shown on p. 76. In filling in this table remember that column H includes column P, and that any work done to assist another field camp in completing a block is not to be entered in column H, but shown in the Remarks column.

In column A the camp officer must fill in the names of himself and his assistants, showing opposite each name the number of man-days of each individual (columns B to G). These must be totalled at the foot. In columns H to V only the total work done by the camp is to be entered.

X. List of astronomical latitudes and azimuths observed, giving place (and beacon), date, result, and number of star or sun observations for each.

XI. List of secondary heights fixed, giving place (and beacon), and where fixed from.

XII. Give (but not in the table) an approximate record of each native surveyor's work in traverse miles and plane-table square miles.

XIII. Specify the special work given in column G, if any.

XIV. A list of the survey beacons and bench marks on permanent walls, etc., giving the number and pages of the field note-book in which their description is given.

XV. Total number of old survey marks inspected, 83 (j), and the number and pages of field note-book in which their description is given.

XVI. General remarks on the season's work.

XVII. Criticisms, additions, and suggestions *re* the regulations and instructions in the Survey Handbook with a view to increasing the efficiency of the Southern Nigeria Survey.

Place and date. *Signature.*

WORK DONE BY..DURING FIELD SEASON 19......

A	Number of Man-Days.						H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
	B	C	D	E	F	G																
Executed by.	*Preparation and Finishing up at Headquarters.*	*Travelling to and from Headquarters.*	*Resting.*	*Sick.*	*Topographical Work in Field.*	*Special Work.*	*Number of Square Miles of Topographical Survey completed.*	*Miles of Theodolite Traverse.*	*Miles of Primary Compass Traverse.*	*Miles of Secondary Compass Traverse.*	*Miles of Tertiary Compass Traverse.*	*Miles of other Compass Traverse.*	*Miles of Plane Table Traverse.*	*Total Miles of Traverse.*	*Square Miles of Plane Table Survey.*	*Miles of Topographical Level.*	*Square Miles of Minor Triangulation.*	*Number of Survey Beacons.*	*Number of Secondary Heights.*	*Number of Latitudes.*	*Number of Azimuths.*	*Remarks.*

(c) The group officer will make out the report of his own camp's work in exactly the same way as done by the camp officer. He will then compile on the table mentioned in IX. a report for the whole group, entering in column A the field camps, but not the names of individuals.

The group officer will further supply a rough tracing on tracing linen of each field sheet, showing survey lines and areas as follows. No detail or names to be shown. The tracing should show the blocks allotted to each field camp.

(*a*) Main framework in black, fixed points in black, triangles with distinguishing numbers.

(*b*) Primary theodolite traverses executed by the camp in black dotted lines.

(*c*) Secondary theodolite traverses in black chain dotted lines.

(*d*) Primary compass traverse in red lines.

(*e*) Secondary compass traverses in red dotted lines.

(*f*) Tertiary compass traverses in blue lines.

(*g*) Area surveyed by rope, and sound and pace, traverses in light red wash.

(*h*) Area surveyed by plane table in green wash.

(*i*) Plane-table traverses in green lines.

(*j*) Triangulation in green dotted lines and triangles.

(*k*) Minor triangulation in brown lines and triangles.

(*l*) Topographical levels surveyed to be crossed by short lines.

(d) Group officers will hand in their reports to the Director of Surveys before reaching the Canary Islands.

(e) If a camp officer is not employed in a group he will furnish a group officer's report.

General Working Hours in the Field.

87. (a) On ordinary working days *actual survey work must commence not later than 6.15 a.m.*, so the time at which the first working parade is held depends on the distance of the camping ground from the scene of survey.

(b) On those days on which it is necessary to shift camp *with all the carriers*, survey work must begin as early as possible; but when only part of the carriers are used in shifting camp, *as should practically always be the case*, survey work must begin at 6.15 A.M.

(c) On ordinary days *no persons*, except the draftsmen, the sick, and men told off for camp duties, *are to be in camp after 6 a.m.; or, on camp shift days, after 6.15 a.m.*

(d) The Director holds all camp officers and surveyors in charge of detached camps personally responsible for the strict observance of the foregoing rules, which are made as much for the sake of health as for prevention of laziness.

(e) Care must be taken overnight that all stores are ready for issue in the morning, as this is a frequent cause of delay.

(f) Work should continue until 3 P.M., the surveyor having his lunch between 10 and 11 A.M.

(g) Under ordinary circumstances work in the field will stop at 3 P.M. and the party return to camp, when the surveyor can ink in his work, do his reducing, take out co-ordinates, etc.

The surveyor, however, should use his discretion. He may find it

more convenient to work from 6.15 to 11 A.M., and again from 1 to 4 P.M., or, on occasion, to work straight through from 6.15 A.M. to 4 or 5 P.M., in order to finish a particular piece of work and so avoid a long march back to it on the following day.

(h) In the field the number of rest days per month should not exceed two complete days, but surveyors can use their discretion in adding to this by allowing sometimes, but not always, their gangs to rest for the remainder of the day after moving camp.

88. (a) Correspondence is dealt with in para. 30.

(b) A camp officer will send a messenger every Monday to his group officer to receive his mails and instructions.

(c) The group officer will send a weekly messenger to his field depôt to receive the mails of his group. The day of the week on which such messengers should reach the field depôts depends on the day the mails are despatched from Headquarters. The last-named day must therefore be fixed by consultation between the group officer and the Chief Assistant before the former takes the field. A list of the days on which the various group camp messengers reach their respective field depôts will then be published by the Chief Assistant in a survey circular to facilitate inter-communication between groups.

Postal and Inter-Communication.

(d) Inter-communication between camp officers will usually be through their group officer, but on many occasions it will be more convenient for camp officers who are working on adjoining sheets to arrange with some local chief, schoolmaster, merchant, or missionary to act as a temporary post office, where messengers can leave, or call for, letters exchanged between the field camps. Camp officers must always be on the look-out for such opportunities as they greatly facilitate inter-communication.

(e) It is the duty of camp officers working on neighbouring sheets to keep each other informed of their whereabouts and of their probable movements during the next fortnight. There is no necessity to go into detail, an approximate area being mentioned. In describing this area, and in all cases, camp officers will be careful to use names that are on existing maps, which are in everyone's possession, and not names of new villages they have discovered.

(f) Surveyors will find it safer to have all letters addressed to them at Survey Headquarters, Lagos, whence they can be forwarded, rather than to their field-camp address.

(g) The post will be used wherever possible.

(h) Messengers will not usually be sent by rail. They may be sent by steamer if no other way is practicable.

89. (a) In preparing his field sheet, as described in para. 60, a camp officer first plots certain geographically fixed points of the framework. These geographically fixed points usually consist of all main trigonometrical points, of "ruling points" on the theodolite traverses, and of certain other points on the theodolite traverses. A description of the method of plotting them is given in para. 90.

Plotting the Main Framework.

(b) Between the geographically fixed points the traverse or trigo-

nometrical detail is plotted by co-ordinates, the traverse being adjusted if necessary, as described in para. 188.

(c) If traverse legs are very short it is only necessary to plot about every fifth station on the field sheet. Care should however be taken to plot all stations from which the field book shows that detail is fixed. If an auxiliary sheet of the traverse exists it is only necessary to plot about every tenth to twentieth station. The pantagraph or eidograph can be used to place the remainder of the traverse on the plotted stations.

(d) Traverse stations plotted should be shown by the proper conventional sign, and numbered where necessary.

(e) All trigonometrical points, intersected points, and traverse stations will be given same numbers as on the Chart, 255 (d).

(f) Important notes are given in para. 63 (b).

Plotting Geographical Points.

90. Geographically fixed points will be plotted from the nearest graticule, their position in feet being calculated as follows from Tables III. and IV.

Example.—Plot the position of A, 6° 15′ 45″ (north) and 4° 32′ 10″ (east).

(a) A is 45″ north of the parallel of 6° 15′.

By interpolation in Table III., 1″ = 100·777675 feet at 6° 15′ 15″ (north). Therefore 45 × 100·777675 feet will give the distance which A is north of 6° 15′, *i.e.*, 4533·89 feet.

(b) It is quicker to use logs, the log for 100·777675 feet being taken from the table—

log 100·777675	= 2·0033643
log 45″	= 1·6532126
log distance	= 3·6565769
Distance	= 4533 feet.

(c) The calculation *should be done both ways as a check.* In the example given above, the value of 1″ was taken at 6° 15′ 15″, the mean between the latitude of A and 6° 15′. This is a refinement that affects the result very little. It would have been sufficient to have taken the value of 1″ at 6° 15′ or 6° 16′.

(d) By a similar calculation, using Table IV., the distance of A east of the meridian 4° 30′ can be found.

(e) The above calculations will all be neatly made in the field note-book for future reference.

Adjusting Compass Traverses on Field Sheets.

91. (a) In the following examples, which are merely given as a guide to camp officers in adjusting their compass traverses to the framework, I., II., and III. are fixed points on the framework. *See* Fig. 4.

First Example.—A compass traverse is run from I. to II. The position of II. by the compass traverse plots at 2. If the chaining has been good, 2 will swing on to II., using centre I. and radius I.—2.

Second Example.—If 2 does not swing on to II., the compass traverse should if possible be adjusted by running a compass traverse from III. to some point on it, say A.

The position of A by the first compass traverse plots at *a* ; by the second compass traverse at *a'*.

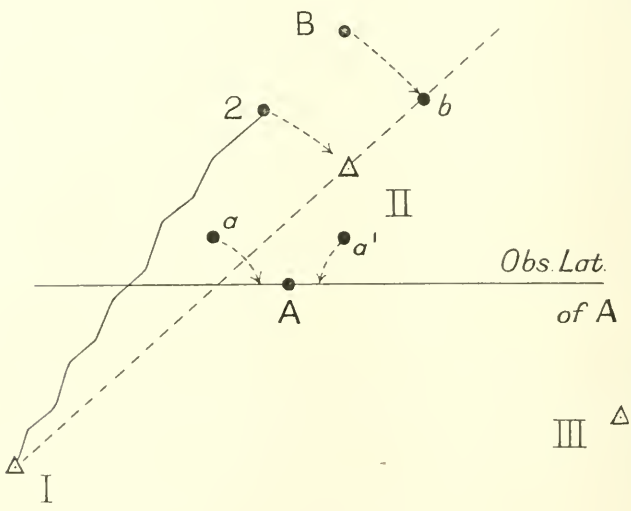
Observe the latitude of A, and swing I.-*a*, II.-*a*, and III-*a'* on to it.

The mean position on the parallel can then be accepted, and the three lengths of compass traverse leading from I., II., and III. to A adjusted.

Third Example.—If the compass traverse from I. to II. plots out to B, swing B on to the line I.—II., produced if necessary. Then reduce the traverse proportionately, so that I.—*b* fits I.—II.

(b) The third example will be found most useful in adjusting tertiary and rope traverses. It ought seldom to be necessary in

Fig. 4.
Adjusting Compass Traverses



higher class traverses, and a primary compass traverse which requires adjustment in this way ought to be regarded with suspicion, and not adopted until every effort has been made to localise the fault, as in the second example.

(c) Latitudes are of great value in adjusting compass traverses when a close cannot be effected, or when the fixed points on the framework are far apart, say from 20 to 40 miles.

In the latter case, a combination of observed latitudes with closes of other compass traverses of like class must be intelligently applied by the camp officer. Latitudes are of greatest value when the traverse runs east and west, and of little value when they run north and south.

(d) Primary and secondary compass traverses ought seldom to be far out, but unknown local attraction may exist. In most cases the mean latitude and longitude of a point common to the two traverses, as given by their co-ordinates, is accepted, but in cases of serious discrepancy a latitude should be observed.

(e) *Adjustment* can be combined with *Reduction* in the majority of cases. *See* next paragraph.

92. (a) Reduction of auxiliary sheets will usually be done by the field pantagraph. When a pantagraph is used for a reduction which is not shown on the scales marked on the arms, care must be taken when adjusting the clamps to maintain the correct proportions.

Reductions.

(b) A simple and expeditious method when no pantagraph is available is as follows:—

Suppose in Fig. 5 it is desired to reduce the compass traverse AB (scale, 1 : 12,500) to the standard field-sheet scale (1 : 62,500).

Take a point P so that AP = BP; join AP and BP (AP should not be less than AB).

Take important bends in the road, say C and D; join PC, PD.

Make Pa = $\frac{1}{5}$ PA, and make Pb = $\frac{1}{5}$ Pb.

Draw ac parallel to AC, and bd parallel to BD.

This gives the points c and d. Similarly any other points can be obtained..

It will be noticed that Pa can be made any proportion of PA, so that this system can be used to combine the operations of adjustment and reduction.

(c) When no pantagraph is available, Fig. 6 shows a simple and, with practice, fairly expeditious way of reducing a drawing with proportional compasses.

I. A B C D E F is a rope traverse plotted on the auxiliary sheet (1 : 12,500) run between two fixed points A and F.

A′ and F′ are the plotted positions of A and F on the field sheet (1 : 62,500).

II. Join A—F and A′—F′.

On measuring we find AF to be 11·4 inches and A′ F′ to be 2 inches. It is evident that not enough allowance for wind of path has been made when plotting the rope traverse, for if AF is reduced one-fifth it will be 0·28 inches too long.

III. Bisect AF and A′F′ at 2 and 2′; adjust the proportional compass so that A—2 = A′—2′.

IV. Select B, C, D and E as salient points on the traverse and drop perpendiculars from them by the set squares on to AF.

V. Using the proportional compass as adjusted in III, reduce Ab to A′ b′, 2—c to 2′—C′, 2—d to 2′—d′ and F—e to F′—e′.

Draw perpendiculars from b′, c′, d′ and e′.

Reduce bB to b′ B′, cC to c′ C′, etc., and so obtain B′, C′, D′ and E′.

VI. Join AB and A′ B′.

The road from A′ to B′ can be put in by eye, but the road junction at 3′ ought to be plotted with the proportional compasses from A′ or B′.

VII. Join B—C. The points 4′ and 5′ can be obtained by proportional compass from B′ and 2′ respectively, and the road put in by eye.

Fig. 5.

Reducing

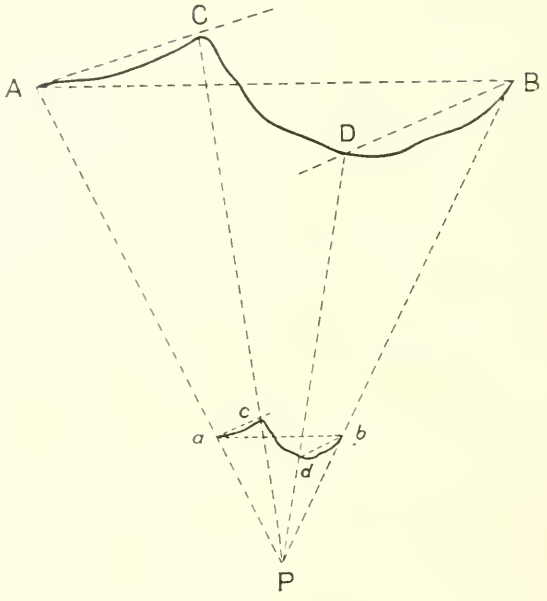
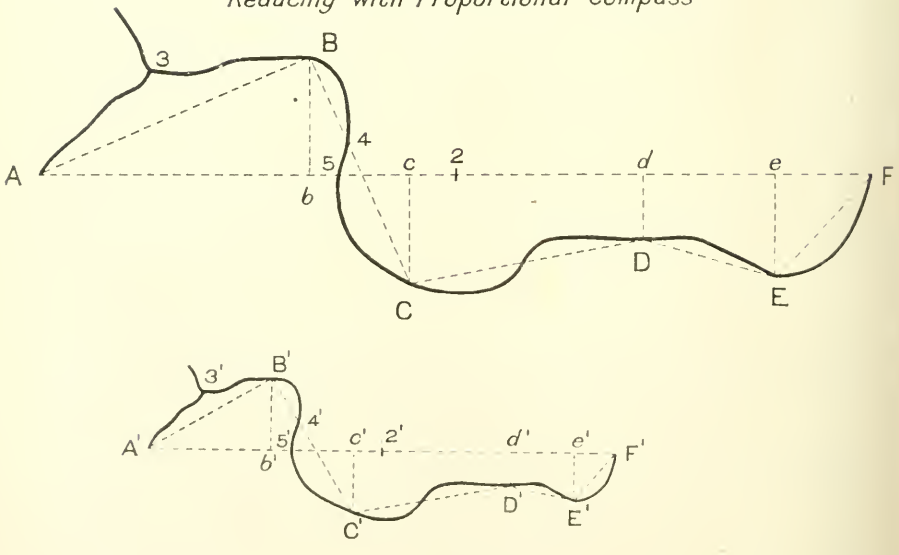


Fig. 6.

Reducing with Proportional Compass



Note. *AF should be 5 times A'F' but for the sake of clearness has not been drawn in this proportion*

Similarly for the remainder of the path.

Note.—If $AF = 5 \times A'F'$, there is no need to adjust the compass as described in III., but to set it at $\frac{1}{5}$ in the usual way.

It is generally necessary to bisect AF, and sometimes to divide it into more than two equal parts, as the proportional compass is not big enough to span more than about 6 inches and the traverse may be 20 inches long.

Too much precision should not be aimed at in the reduction of the detail, especially in rope traverses. Any error is safely localised by fixing the salient points, road junctions, stream crossings, etc., accurately and putting the remaining detail in by eye.

(d) If no pantagraph or proportional compass is available.

Suppose the line A′—F′ to be 2 miles and A—F to be also 2 miles.

Act as in (c), but instead of the proportional compass use the 1 : 12,500 scale for measuring the various details on AF in feet, and transfer these measurements in feet by the 1 : 62,500 scale to A′F′.

(e) But if in the example in (d) A′—F′ is 2 miles and A—F is not exactly 2 miles, then a scale of feet must be made for AF.

Make this scale by taking AF as being 2 miles and divide it up to get feet.

Then carry on as in (d).

Supplementary Survey of Framework.

93. It occasionally happens that a camp officer finds it necessary to survey the detail of some road previously traversed by some other party when forming the framework. In this case the camp officer must plot the original traverse by co-ordinates in pencil on an auxiliary sheet, showing all detail given in the field book in pencil. He can then run a rope traverse along the road to obtain the detail up to date and adjust his results to the original plot.

CHAPTER III.

COMPASS TRAVERSES.

100. (a) *Compass Work in Forest Country.*—Compass traverses cannot be regarded otherwise than as an evil necessitated by the presence of the dense scrub, forest, and mangrove belts in Southern Nigeria. In these belts triangulation and plane-tabling are impossible except over areas so small and isolated as to be practically negligible when considering the system of survey. The framework in these belts has consequently to be constructed by theodolite traverses and instrumental levels, and the topographical detail of the country filled in by compass traverses and barometer heights.

Remarks on the Compass Survey of Southern Nigeria.

(b) *Compass Work in Triangulated Country.*—Similar conditions apply, though with less force, to the detail survey of the southern portion of the belt of country covered by the main triangulation of Southern Nigeria, *i.e.*, the part where the forest belt gradually merges with the open plain country. In a few places the change is so sudden that the plane table can be at once used. Generally speaking, however, there is a belt of mixed country, difficult to define exactly, from 15 to 40 miles wide, with scattered hills usually topped with forest, lying on undulating plains, sometimes open but generally covered by patches of scrub, forest, and palm trees.

In this belt it is practically impossible to make a complete plane-table survey. The detail work has to be done by compass with occasional use of the plane table, and the framework is supplied by the trigonometrical points.

(c) *The Chief Disadvantages of Compass Traverses* are inaccuracy in angular measurements and slowness of execution (or cost) when compared with plane-tabling.

(d) *The Disadvantage of Inaccuracy in Angular Measurements* is minimised by the rules that (1) every compass traverse *must start and end at "Fixed Points" on the framework* (or on points already determined by a compass traverse of higher class); and (2) local magnetic variation must be systematically determined at intervals (para. 115).

(e) *The Disadvantage of Slowness* (or cost) is met by dividing compass traverses into six classes, varying in accuracy and therefore in rapidity of execution, the more accurate being used to form a compass framework, the more rapid for detail.

101. The extent to which each class should be used varies in each field sheet and depends so much on the amount of framework

existing locally and the nature of the bush that it is impossible to lay down any exact ruling on the subject. *Group officers must, in arranging the proportion of high class traverses they use, bear in mind the necessity of economy*, and the following rough rules.

Proportional Use of Classes of Traverse.

I. *Primary.*—The main framework may, if it is very deficient, be supplemented by a primary compass traverse framework. Primary compass traverses are, however, so slow in execution that *they are very rarely used, and then only when specially ordered by the Director.*

A primary compass traverse framework consists of from one to two primary compass traverses, run if possible along the best roads or along the beds of the larger streams when partly dried up. The ends of each traverse to be tied to the main framework, and further checks secured by arranging for the traverses to cross each other, and by an observed latitude on two pairs of north and south stars at one or more places on them, preferably at the point of crossing.

II. *Secondary.*—The main framework is usually supplemented by a secondary compass traverse framework, consisting of from two to four secondary compass traverses tied to points on the main framework or to points on the primary compass traverse framework if one exists.

Secondary compass traverses should seldom be necessary in country where sufficiently long legs can be obtained to run a reliable tertiary or plane-table traverse.

III. *Tertiary.*—In forest country, where the legs are short, tertiary compass traverses are used to break up the blocks already formed by the secondary compass traverses into sufficiently small areas to allow of the use of "rope" and "sound and pace" traverses.

In country where sufficiently long legs can be obtained tertiary compass traverses are used instead of secondary traverses, the compass framework being practically entirely constructed of them and plane-table traverses.

The number of tertiary compass traverses will probably not exceed about ten per field sheet, and the ends of each will be tied to points on the framework already existing.

IV. *Rope Traverses* are to be used for three chief purposes—

(*a*) For filling in the topographical detail of the blocks into which the field sheet is divided by the framework. *Over 90 per cent. of the detail on each field sheet should be surveyed by rope, or sound and pace, traverses.* In all cases the rope traverse must begin and end at fixed points on the main or compass frameworks.

(*b*) Their second chief use is for *rope partals for breaking up an area which*, owing to dense forest and the absence of paths and streams, would otherwise form an unsightly blank on the map. A rope traverse can be very rapidly run across such an area, only sufficient clearing being done to enable the surveyor to push his way through the undergrowth, and will at any rate result in determining the form-lines in the area even if no other detail is obtained. The number of rope partals to be run is left entirely to the discretion of the camp officer, who will naturally be anxious to have as few blanks on his field sheet as possible, and expense

can be avoided by employing first-class headmen (or pupils undergoing field training) on the work. Surveyors must bear in mind that a rope traverse of a stream is of greater topographical value than a rope partal across country, even though the course of the stream may not break up the blank so satisfactorily.

(*c*) *Semi-Partals.*—In para. 75 (d) mention is made of the fact that, owing to the expense of clearing, the only fixed points on form-lines in dense forest are those on roads, streams, and surveyed lines. On occasion, however, a surveyor may want to know the approximate course for a short distance of some form-line after it enters the forest (so as to join up his form-lines, for instance, in some intricate piece of country). The rope traverse and barometer are very useful and expeditious in determining this, and the traverse may end in the air, in which case it is called a "*semi-partal.*"

(*d*) *Semi-partals should be extensively used to localise hills and streams lying off the path in dense forest.* If it is found on reaching a hill-top that a good view is obtained of other features, whereby the hill-top might at some future time be useful for extending the trigonometrical survey, full bearings with approximate ranges and a rough profile sketch should be made and forwarded by next mail to Headquarters.

(*e*) Semi-partals are also very useful in the survey of small streams. *See* para. 79 (e).

Primary Compass Traverse.

102. (a) A 4-inch compass (or larger) on tripod. *Forward and reverse bearings* of each leg read to nearest 5′; mean taken, and variation of compass substracted. Legs measured to one decimal of a foot by 100′ or 200′ steel band checked by 66′ steel band. (Para. 109.)

(b) *Co-ordinates* to one decimal of a foot taken out of Gurden's or Boileau's Traverse Tables for the nearest minute, and checked for gross errors by Chambers' Latitude and Departure Tables for the nearest foot and degree. This work can well be done during halts or in the evening. The co-ordinates should be divided into sub-sections, as described in the next subparagraph. Each traverse should be given a distinguishing "section number," the subsections being further distinguished by letters.

(c) *Traverse plotted by protractor*, leg by leg, on the auxiliary sheet as work progresses, and all detail put in. Some surveyors prefer plotting this auxiliary sheet by looking out the latitude and departure in Chambers' at the time, the figures thus obtained being entered on a spare page in the field book, and afterwards used as the check mentioned in (b).

Several sections of the track under survey may be plotted on one auxiliary sheet, the length of the sections usually being decided automatically by the size of the paper. In many cases it is advisable to terminate a section at some point, such as an important road junction or river crossing, in order to facilitate adjustment.

The co-ordinates of the traverse should be divided into sub-sections, each corresponding to a section of the plot. This immensely facilitates reduction and fitting on the field sheet, as described in the next subparagraph.

(d) After the traverse has been closed on the framework, *the draw-*

ing on the auxiliary sheet is transferred (reduced, if necessary) *to the field sheet.* It is not necessary to plot all the co-ordinate stations on the field sheets, only the last stations of each subsection being plotted. The traverse plan on the auxiliary sheet, especially if plotted by Chambers', will usually be found accurate enough to be transferred subsection by subsection as it stands to the accurate skeleton formed by the above-mentioned "last stations," pantagraphs or proportional compass being used for reduction.

The value of this method is apparent. To begin with, the "last stations" are plotted. Then, when *the last station of the whole traverse* has been adjusted to the framework, the positions of the "last stations" are also adjusted, often automatically, but sometimes by the proportional adjustment of the closing error of the co-ordinates through the subsections. The positions of the "last stations" thus being correctly obtained, the subsections on the auxiliary sheet are reduced directly on to them, as before described.

(e) *Approximate rate of survey*, including all plotting, computing, and transferring to field sheet, is about 2 miles a day in forest country, with average legs of 150′ to 250′. This rate includes surveying all surrounding detail.

(f) When used, *see* para. 101, I.

(g) For *Adjustments*, *see* para. 91. For *Reductions*, *see* para. 92.

Secondary Compass Traverse.

103. (a) A 3½-inch compass (or larger) on tripod. *Forward and reverse bearings* of each leg read to the nearest ¼ degree; mean taken, and variation of compass subtracted. Legs measured by steel band to one decimal of a foot and checked for gross errors by pacing.

(b) *Co-ordinates* taken out of Chambers' Latitude and Departure Tables for the nearest degree and foot and divided into subsections, as in para. 102 (b).

(c) *Traverse plotted on auxiliary sheet*, as in para. 102 (c).

(d) *Drawing transferred to field sheet*, as in para. 102 (d).

(e) *Approximate rate* 3 to 4 miles a day in forest country, with average legs of 150′ to 250′, including survey of all surrounding detail, plotting, computing, transferring to field sheet, etc.

(f) When used, *see* para. 101, II.

(g) For *Adjustments* and *Reductions*, *see* paras. 91 and 92.

Tertiary Traverse.

104. (a) Any compass, held in the hand or on tripod. *Forward and reverse bearings* of each leg read to the nearest degree; mean taken, and variation of compass subtracted. Legs measured by steel band to the nearest foot and checked for gross errors by pacing. (*See* para. 113, Method B.)

(b) *No co-ordinates used.*

(c) *Auxiliary sheet plotted by protractor*, as in para. 102 (c), and *transferred to field sheet* when the traverse is "closed." As no co-ordinates are used, and as the accuracy of the survey depends entirely on the plotting, the surveyor must be careful to use a sufficiently large scale, and to use his dividers and the diagonal scale on the S.N. Protractor when plotting the length of the legs.

If he is using a scale not given on the protractor, he can quickly construct a suitable diagonal scale on a piece of section paper. The S.N. Protractor is sufficiently accurate for plotting bearings, the chief error in tertiary surveys arising from inaccuracy in plotting measurements.

It should be noted that the same system of reducing and fitting can be used as described in para. 102 (d), for, though no co-ordinates exist, yet very efficient substitutes can be obtained by measuring the latitude and departure of the "last stations" of each subsection on the auxiliary sheet with a plotting scale, and then carrying on exactly as if these co-ordinates had been obtained by figures.

Reducing and adjusting can be combined in one operation. (*See* para. 92.)

(d) *Approximate rate* 5 to 6 miles a day in forest country, including all plotting and transferring to field sheet, and the survey of all surrounding detail. Average legs, 100′ to 300′.

(e) When used, *see* para. 101, III.

(f) A "lead-line" rope may be substituted for the steel band in tertiary traverses.

"A chain made of 'lead-line' rope, well stretched and tarred, will glide through a forest like a snake. One end should be formed into a loop, to aid the man in dragging it, and small strips of leather let in between the strands at 10-feet intervals for the odd measurements.

"The length of the rope should be tested daily both before and after work with a standard band, but it has been found in practice that a well-seasoned rope does not alter much in length and wears well."—(S.I.)

(g) A perambulator may be substituted for the steel band on smooth paths in tertiary traverses. (Para. 107.)

(h) The tertiary plane-table traverse described in para. 213 (d) may be substituted for the tertiary compass traverse, but *not* on the more important parts of the minor framework, owing to the fact that, no field books being kept, no check on the plotting is possible.

105. In both these classes of traverse no clearing is done and *the bearing is taken to a sound not a visible object.*

Rope Traverses and Sound and Pace Traverses.

(a) *Rope Traverse.*—A 1-inch rope or thin wire hawser, about 100 yards long, is used. Five natives are necessary. (*See* para. 52, Table V.) No. 1 puts his shoulder through a loop in the rope and drags it along the path. No. 2 follows at the back end with the surveyor.

(b) When the rope is full stretch No. 2 holds tight and cooeys, No. 1 stops pulling, drives an arrow or short stick into the ground, and cooeys. The surveyor *takes the bearing of the sound* (as No. 1 is invisible to him) and enters it in his field book. (If a plane table and trough compass are being used, as in subpara. (r), the alidade is directed on the cooey and no field-book entry is necessary.)

(c) The surveyor whistles, No. 1 advances with the rope until No. 2 reaches the arrow, when he holds tight and the procedure in (b) is repeated.

(d) The surveyor paces the leg in order to put in the detail, and also to avoid missing the arrow, which is easily passed unnoticed in

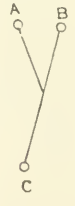
very thick undergrowth even when there is, *as there should always be*, a bright cloth attached to it.

(e) at intervals No. 1 is supplied again with the arrows he has left behind.

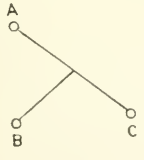
(f) In plotting, an allowance of from 2 to 4 per cent. has ordinarily to be made for wind of rope. This allowance can only be fixed by experience. After executing two or three rope traverses, the surveyor ascertains by his closing error if he has made the right allowance for wind of rope, and so gains an experience that will probably enable him in future to estimate it correctly. The rope winds considerably less than the actual path does, for being pulled taut, it strengthens itself between trees, etc., at the bends of the clearing, whereas the path itself winds about along the clearing. If it is considered that the wind is about 3 per cent., the rope should be made 103 yards long and always plotted as 100 yards—an automatic allowance. 3 per cent. is, as a rule, a large allowance; on fairly good bush tracks 2 to 2½ per cent. is a fair estimate of the wind.

(g) *Errors.*—This system of traversing is not so inaccurate as may be supposed, but serious errors are likely to arise when the path or stream bends right back on itself, or is, for portions of its length, quite straight, but the surveyor, in time, will get into the habit of rapidly allowing for these variations, and making deductions or additions for exceptional circumstances as well as the automatic allowance mentioned in (f). Errors are, however, minimised by limiting the length of a rope traverse, *see* (h) and localised by the framework. Examples of combined adjustment and reduction are given in para. 92.

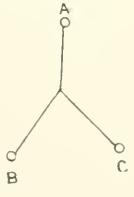
(h) *Limit of Length.*—A rope traverse may be 7 miles in length if both ends are tied to the framework. It may be 10 miles in length if both ends are tied to the framework, and, in addition, a point about half way along it is tied to a third point on the framework by a rope traverse not exceeding 5 miles in length, always provided that a "good figure" for adjustment is so obtained. Example, A, B, C, being points on the framework.



BAD.



FAIR.



GOOD.

When two rope traverses, each starting from a point on the framework, are used to localise a point from which no further traverse is possible, each traverse must not exceed 3½ miles in length.

(i) The rope must be frequently tested and its length adjusted.

(j) Rate of rope traverses. 8 to 10 miles (130 to 180 stations) a day on good paths, 6 to 8 (100 to 130 stations) on bad paths, 4 to 6 miles (70 to 100 stations) a day on rope partals or along streams in thick bush.

(k) When used, *see* paras. 101, IV., and 117 (i).

(l) *Sound and Pace Traverses.*—These are executed somewhat on the principle of the rope traverse, are very rapid, and if due care is taken to tie them at both ends to surveys already made, are sufficiently accurate for unimportant paths.

A sound and pace traverse should not exceed 3 miles in length, or, if tied from somewhere near its centre to a third point on a previous survey, by a line not exceeding 2½ miles in length, 5 miles. It should not be forgotten, however, that all three lines leading from this central point should be proportionally reduced or enlarged where such process is necessary.

(m) The surveyor requires a "back man" a plane-table boy, and a runner.

He starts at point A on the framework, where he places his back man. Accompanied by his other two boys, he walks a certain number of paces along the track until he reaches B. He halts, puts in an arrow, and cooeys. The back man cooeys, the surveyor takes the bearing of the sound, books it opposite B as a back bearing, and whistles twice for the back man to come up. After the necessary entries in his field book the surveyor goes on pacing, the back man comes up to B and the process is repeated.

The forward bearing can be calculated later and put opposite its correct station, *i.e.*, *the station from which it is the forward bearing*, but in all cases the surveyor must be careful to book his back bearing at the time he reads it—*opposite the station at which he then is.* *See* sub-para. (r).

(n) The number of paces may be any convenient number, but, as a rule, it is not advisable to take more than 300. If a surveyor knows his pace is worth 2½ feet he might always take 200 paces, an easy number to plot, *i.e.*, 500 feet. Or, if he estimates the wind of path as 5 per cent., a good average allowance, he should take 210 paces, *i.e.*, 525 feet, and plot as 500 feet.

(o) The auxiliary sheet need only be plotted up to date where detail occurs.

(p) The rate of sound and pace traverses is about 25 per cent. quicker than that of rope traverse, *see* (j).

(q) When used, *see* para. 101, IV., but sound and pace traverses are of no value for partals, on account of the difficulty of pacing.

(r) All field-book entries can be saved (except those in village and river field books) by using the plane table and trough compass as if a tertiary plane-table traverse was being run. Para. 213 (d). The alidade can be directed on the sound.

This applies both to rope, and sound and pace, traverses.

Time Traverses

(s) The fifth class of compass traverse scarcely forms part of the system of topographical survey of Southern Nigeria, but a description of it is given here as it is of use when marching long distances daily in unmapped country. As will be seen, a time traverse is quite unreliable as a survey, but forms a valuable guide for future survey parties, travellers, etc.

(t) The surveyor walks, rides, or hammocks near the tail of the column, and a reliable native (with a watch if possible) from 300 to 500 yards ahead of him, this interval being fixed merely by the distance sound will carry.

(b) Every ten minutes or so the native blows a horn, or whistles, or cooeys. The surveyor books the time and approximate bearing (probable error of 5° either way). *See* form at end of paragraph.

(c) Surveyor books time he passes any stream, road-junction, etc., also time of halting and resuming march at long and short halts and at checks, etc. *See* para. 107 (c).

Note.—A mistake commonly made by beginners is that they think that they must take a bearing again when they reach the spot where the leader cooeyed. This is not necessary. The leader may cooey and the surveyor take the bearing anywhere. The object of the bearing is merely to get the approximate direction of the route, and, if no compass is available, the surveyor can tell the direction roughly by the sun or stars as N., N.W., N.W. by W., W. etc. In rough exploratory surveys of this nature in Ashanti the traverse was subsequently proved by the map to be accurate in length to within 100 yards in a distance of 39 miles, but several of the intermediate villages were from ½ to 1 mile out of position. In other cases the errors did not balance, as, for example, when the rate of marching on muddy paths after a tornado was overestimated, and the total traverse of the day's march was 4 miles in error. Similar instances of "fluking" accuracy and of considerable errors were found in direction.

(d) The bearings are plotted during halts or in the evening with a protractor in the usual way. This should be done while the day's work is fresh in the memory, and it should be stated whether true or magnetic bearings are used and a north point given.

(e) A paper scale to suit the rate of march can quickly and easily be made.

Example.—Suppose rate = 2½ miles per hour, and that the scale of survey is 1 inch = 2 miles (this is roughly the scale of the standard map 1 : 125,000, and may be taken as such).

If the surveyor marches 2½ miles in 1 hour, therefore he marches 2 miles in 48 minutes (I.)

On the map 1 inch = 2 miles.

Therefore, by (I.) on the map, 1 inch = 48 minutes.

5 inches = 240 minutes (II.)

FIG. 7. EXAMPLE OF SCALE.

Minutes at 2½ miles per hour. *Scale, 1 inch = 2 miles.*

Draw a line 5 inches long and divide it into six equal parts as above. Then each part represents forty minutes' march.

Divide the end part on the left into four equal parts, each representing ten minutes' march.

The ten-minute parts can afterwards be divided up to show, say, a march of two minutes, but this is too great accuracy considering the

inaccurate method of survey, and distances of less than ten minutes can be interpolated from the above scale.

(f) Where paths leave the main road, villagers should be asked where they lead to, and to point towards the place, the bearing of the direction being entered in the field book.

(g) Example of field book for time traverse :—

	40	7.18	$2\frac{3}{4}$	
	45	7.8		
		O K O	Halt.	Sma l village. 5 compounds.
		7.0		
	35	6.57		
~~		6.50	$2\frac{3}{4}$	Stream 15 feet wide.
	29	6.47		Good water, running.
Road to Ori.	25	6 37		
280° (1 house?)			Halt.	
		6.27		
	20	6.25	$2\frac{3}{4}$	
	25	6.15		
			$2\frac{1}{2}$	
	17	6.5		
	O F	A D A		Town. 400 compounds.
	18	th May, 19	10	
Road to Ori.				
345° (1 house?)	*Bearing.*	*Time.*	*Rate.*	

Further example in *Close*, pp. 276 and 277.

107. (a) A good measuring wheel can be used for measuring the legs in tertiary traverses, but *smooth roads are absolutely necessary* for accuracy. When used instead of a rope in rope traverses it gives less accurate results on bad paths.

Perambulators.

(b) A bicycle with cyclometer forms a good perambulator for rapid surveys on good roads, and some surprisingly accurate results

were got by this system in East Africa when long rays were obtainable.

(c) As a substitute for a time traverse the bicycle cyclometer is very useful, the bearing of the general direction of the path being taken at intervals when in the forest, and of distant points on it when in the open.

(d) Perambulators, whether bicycles or measuring wheels, should be frequently tested on level measured lengths.

Standard Methods of Chaining.

108. All chaining in the Southern Nigeria Survey is executed with steel bands, ½ inch in width, and in lengths of 100 to 500 feet, standardised at 63° F. The method of chaining varies according to the accuracy of the class of survey, as follows:—

Invar Base Method.—For measurement of trigonometrical bases only (Chapter VIII.)

Double Chaining.—In primary compass and plane-table traverses, and with additional refinements in theodolite traverses.

Single Chaining.—In all other topographical traverses.

Double Chaining.

109. The following method of "long and short" chaining is used with primary compass traverses.

(a) Three steel bands are used. The first band is for *measurements*, and is called the "long band." It may be from 100 feet long, 200 feet being the most convenient in forest country. It is marked by brass clips at every foot. The second band is the "short band" (66 feet marked in links) for checking. The third is a 100-feet band *for use as a standard only.*

In addition there is a steel rule marked in twentieths of a foot.

(b) A 15 lb. pull is used.

(c) No temperature correction except in theodolite traverses.

(d) Correction for slopes (para. 111).

(e) Three chainmen for the long band, and two, the most skilful, with the short band.

(f) The surveyor measures the leg with the long band, recording intermediate readings, offsets, and slopes, and, on arrival at the forward station, books his total distance in feet.

(g) The chainmen with the short band follow the long band, and the surveyor books their result in "chains" and "links" under the long band result.

(h) The surveyor checks by reducing the long band to the short as follows, on the left-hand side of the book, supposing the *long band* to have shown 232·7 feet:—

2·327	equals the long band in hundreds of feet.
1·1635	equals ½ long band in hundreds of feet.
3·4905	equals 1½ long band in hundreds of feet.
·0349	equals the first two figures of the third line removed two places to the right.
3·5254	equals reduced measure in chains and links.

Or he can use Table II. as follows:—

		Chs.	Lks.
232′	equal	3	51·5
0·7	equal	0	1·06
232·7	equal	3	52·56

(i) *Discrepancy.*—If the difference between the long band measurement and the short band measurement does not exceed *one link for every five short bands* (1 : 500), the result given by the long band is accepted; if not the measurement must be repeated with both bands. *The mean* is never to be taken.

In the example given in (h) a discrepancy of 0·7 links would be permissible.

(j) In theodolite traverses the discrepancy must not exceed one link in every twenty short bands, or 1 : 2000 for primary traverses. For secondary theodolite traverses, 1 : 1000.

(k) Notes on chaining and entries in field books are given in paras. 113, 117 (g) and (h), 118.

Single Chaining.

110. (a) Single chaining is executed with steel bands up to 500 feet in length (200 feet is the most convenient), while a second steel band is kept as a standard only.

(b) A 15 lb. pull is used.

(c) No temperature correction.

(d) Correction for slopes (para. 111).

(e) Three chainmen per band.

(f) As in para. 109 (f).

(g) The surveyor paces as a check on gross errors and books this check in paces underneath the band result. *Note.*—A better check is a 100-foot rope.

(h) Surveyor checks by reducing his paces to feet in left-hand side of page. It is necessary that he should have a very good idea of the value of his pace.

(i) Discrepancy must be left to surveyor's discretion on bad roads; on a good path it should not exceed 1 : 30 for a good pacer.

(j) Notes on chaining are given in paras. 113, 117 (g) and (h), 119, 120.

Correction for Slope.

111. (a) The slopes of different lengths of the band on each leg, or the slope of the whole leg, as the case may be, must be roughly taken with a small clinometer or Abney level; the slope must be entered on the left-hand side of the page, using a diagram where necessary, and the correction must be entered in the proper column on the left hand side of the recorded measurement.

Notes on slopes are given in para. 117 (g) and (h), and field-book entries in paras. 118 to 120. Table I. gives corrections.

(b) In primary compass traverses no correction need be applied for slopes of 2 degrees and under. In secondary compass traverses, for 3 degrees and under.

112. (a) The standard band must never be used for any other purpose than checking the bands in use, and must be carefully compared with the Lagos standard before leaving Headquarters by the camp officer. All other bands will be tested at the time.

Checking Bands and Ropes.

(b) On primary compass traverses the steel bands in use must be compared with the standard once a week and at once after repair.

(c) On all other compass traverses once a month and at once after repair.

(d) Ropes will be tested morning, midday, and evening during the first week of their use; after that every morning or evening.

(e) Camp officers must note, and inform the assistant, of the error of any band he issues to him, and make arrangements for its periodical test.

(f) If Gunter's chains are used test every morning or evening, and remove a short link when the error exceeds half an inch.

(g) All errors to be noted in field book on the form provided, para. 117 (b).

113. The following methods of chaining over very rough ground will result in doubling the rate of work, and which, modified to suit length of bands, will do away with the necessity of "clearing up" the ground for the steel band, a process which causes great delay in traversing dense forest.

Supported Bands.

Method A (*see* Fig. 8).—The chain squad consists of:—

1 leader pulling the 500-feet band.
1 follower to hold band at back mark.
(These two are chainmen.)
3 supporters, ordinary carriers armed with 10-feet poles with forked ends.
1 banderole man at forward station.

The leader walks on, pulling the band which is carried by the supporters (stationed respectively at the 50′, 200′, and 350′ marks) above the jagged roots, etc., on the ground.

On the arrival of the follower at the back mark he places the end of the band against the back mark and firmly secures it. The surveyor should see that it is correctly done. A simple way is to make the follower, after he has placed the end of the tape against the arrow forming the back mark, pin the handle to the ground with two arrows placed inside the handle. He can then watch and see that the end of the tape is against the back arrow when the strain is taken on the band, holding the other two arrows firmly with one hand.

The surveyor aligns the supporters on the forward station.

All the supporters place the ends of their poles against convenient trees, and support the band on the horizontally held poles about 3 feet above the debris-strewn ground.

The surveyor, with a gesture or two, gets the poles in one plane, takes the slopes from 0 to 50 feet and from 50 to 500 feet. At 500 feet he takes the proper amount of pull, and, keeping the handle in the line of the plane of the poles, plumbs the forward mark. The operation is then repeated towards the forward station. It is sim-

Fig. 8

Supported Band (Method A)

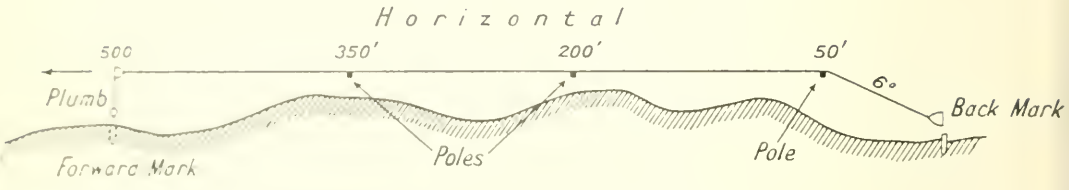


Fig. 9

Supported Band Measuring across a gully

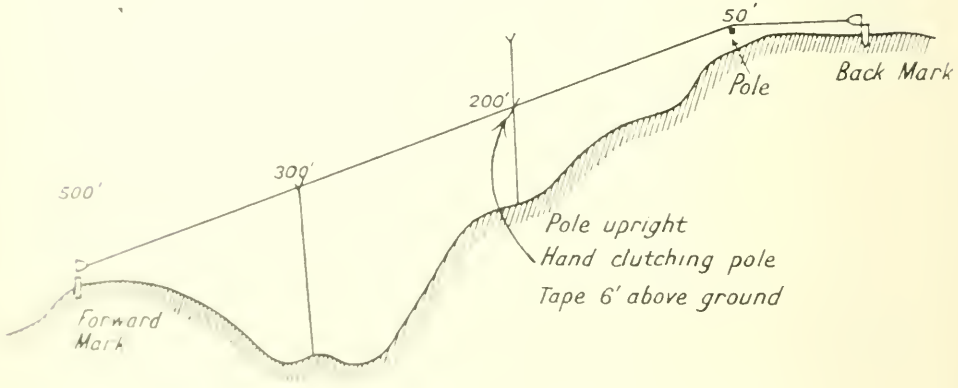


Fig. 10

Measuring with a supported 300' band a leg 232' in length

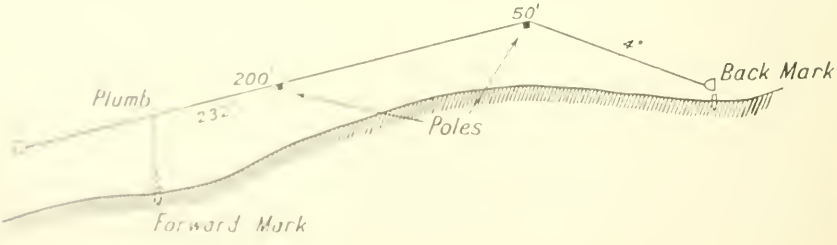


Fig. 11

Supported Band (Method B) Band sloping

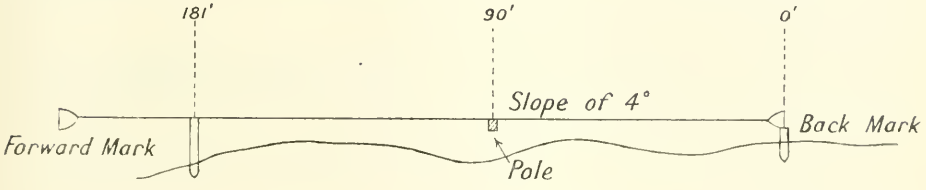
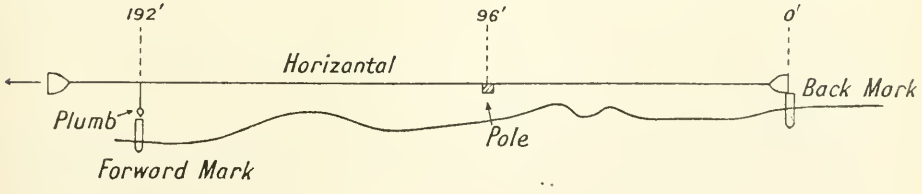


Fig. 12

Supported Band (Method B) Band horizontal



plified if the ground allows the band to be held horizontal from 50 feet onwards, as in Fig. 8.

Slight variations in this procedure are necessitated when the leg is less than 500 feet, or when the band is only 300 feet; but these will readily suggest themselves to the surveyor. Examples are given in Figs. 9 and 10.

As no allowance is made for sag, the method above described is not suitable for very high-class work unless the band is specially standardised, but it is sufficiently accurate for secondary theodolite traverses and all compass traverses.

Method B.—A similar method, as shown in Fig. 11, is very expeditious in measuring with a 200-feet band in secondary and tertiary traverses. 3 chainmen, viz., 1 leader, 1 supporter placed half-way between the stations, or, if the leg is less than 200 feet, half-way along the band, and 1 follower. Longer bands can be used, in which case more supporters must be provided.

The band is stretched from the top of one station picket to the top of the next, supported half-way; pull is taken, band read, and slope observed. If the band is not as long as the leg intermediate points can be plumbed.

Or, what is better still if the ground allows, the band may be supported horizontally and the pickets plumbed at one or both ends, as in Fig. 12.

114. In traversing across rivers or other obstacles where chaining cannot be carried out the surveyor has three courses open to him.

Traversing across Rivers.

(a) If the obstacle is sufficiently narrow to allow the band to be carried across, the distance can be measured direct. Calculations for sag need not be made with $\frac{1}{4}$ inch bands for unsupported distances of 100 feet and under, and with $\frac{1}{8}$ inch bands for 250 feet and $\frac{1}{16}$ inch bands for 500 feet in compass traverse work. In most cases a native with a long forked pole can support the band from a canoe, stranded tree, etc.

(b) If the distance is too great for the above method, a theodolite and subtense bar (or subtense base) should be used, or

(c) Triangulation with theodolite. Measure a base of suitable length, one end of which should coincide with the traverse station, as nearly as possible perpendicular to the line to be measured.

The following conditions must be satisfied:—

I. The base must be accurately measured.

II. All three angles of the triangle must be measured.

III. The vertical angles along each side of the triangle must be observed. (In compass traverses, slopes of under 3° need not be measured.)

IV. The sum of the angles at each end of the base must not exceed 170°. This may often be very inconvenient, if not impossible, in which case more care must be observed in measuring the angles, especially in theodolite traverses, when the surveyor must read all the horizontal verniers, and observe each angle on both faces.

(d) If no theodolite is available, the triangulation can be done with a compass, in which case the sum of the angles mentioned in IV. must not exceed 150°.

It would be waste of time to clear a straight base if the river bank

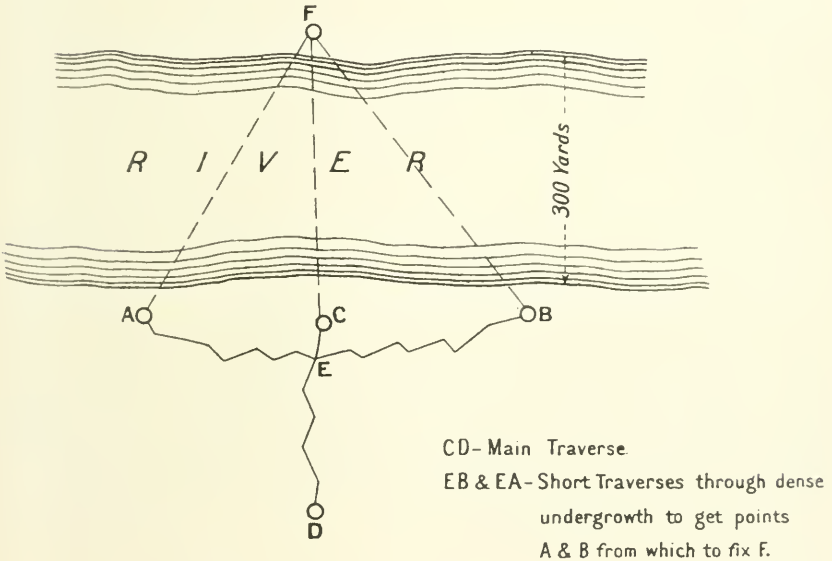
is very heavy with bush, so a short length of traverse line might be run out each way so as to get three points from which to fix the point on the opposite bank, as shown in Fig. 13.

(e) If s = correction for sag in feet
l = length of band unsupported in feet
w = weight of unsupported length in lbs.
t = pulls in lbs.

then $s = l \times \frac{w^2}{24 \times t^2}$

Fig.13

Example of a Traverse Base for measuring a river



115. (a) There are three chief causes which render any bearing observed with a magnetic compass liable to error. These are the personal error of the compass, the amount of local attraction, and the magnetic declination existing locally.

Compass Magnetic Variation.

(b) *Compass Personal Error.*—Some compasses do not read true. This is due to faulty construction, and may be called the personal error of the compass (P.E.C.).

The personal error of the compass is usually so small as to be negligible, but the compass should always be tested before leaving Headquarters and the personal error of the compass noted.

(c) *Local Attraction.*—This is generally caused by the presence underground of iron, etc., in which case, as the cause is invisible, the surveyor may be ignorant that his compass is playing tricks until he closes his traverse on to a fixed point, when there will probably be a serious discrepancy. Frequent determination of the compass magnetic variation, as described in (e), is the only way to ascertain

the presence of local attraction; and, as this is often not convenient, there may be said to be in most countries an unknown error in a compass survey due to local attraction of a more or less serious nature. In Southern Nigeria comparatively little local attraction exists.

(d) *Magnetic Declination.*—This is the angle between the true and magnetic norths. It varies slightly in different parts of Southern Nigeria, and decreases about four minutes annually. It is often spoken of as magnetic variation, but magnetic declination is the correct term.

If there is no local attraction the C.M.V. $\pm$ P.E.C = the magnetic declination approximately.

(e) *Compass Magnetic Variation (C.M.V.).*—In view of the possible causes of error mentioned in (b), (c), and (d), the surveyor must take great care *to check his compass on each field sheet.* This is best done by taking, with the compass, the magnetic bearing of some line of which the true bearing is known. The difference between the compass bearing and the true bearing gives the magnetic variation of that compass. This compass magnetic variation includes the personal error of the compass and the local attraction error, if any, and therefore no allowance need be made for the personal error of the compass when plotting.

(f) In the Southern Nigeria Survey the compass magnetic variation will be determined by taking three forward and three reverse readings wherever a true bearing exists. These readings are to be entered in the field book as shown below at the end of the paragraph, the compass being gently tapped between the readings.

(g) These observations are made on any convenient page of the field book, and the compass magnetic variation entered on the front page, para. 117 (b), and also on the auxiliary sheet. In the entry form, after the word "at" put the place, and after "Azimuth used" say whether an azimuth was observed or whether the recorded azimuth of the two Southern Nigeria Survey Beacons were used. If the latter, state their numbers.

(h) All spare compasses should be similarly tested in case of accident.

Example of Entry of Compass Magnetic Variation.

Compass No. 39. Date, 2nd Jan. 1911.
Observations at Pama.
Azimuth used, Star observation, S.N.S. 11 to 10.
True Bearing = 40° 38′

Forward Bearing	A = 57° 50′	Mean	
" "	B = 57° 40′	57° 45′	
" "	C = 57° 45′		
Reverse Bearing	D = 237° 30′		
" "	E = 237° 40′	237° 35′	
" "	F = 237° 35′		

Mean M.B. = 57° 40′
True Bearing = 40° 38′

C.M.V = 17° 02′ W.

116. (a) *Primary, Secondary, and Tertiary Heights.*—The only accurate method of fixing heights in the forest and mangrove belts is by running lines of instrumental levels, called in Southern Nigeria "topo. levels." This is, however, a costly process, so the number of lines run must be reduced to a minimum, and the remainder of the forest country contoured by aneroid barometers. *The form-lines in the open country are determined by plane table and telescopic alidade, as described in Chapter VI., but the aneroid is also used as an auxiliary.*

Barometer Heights.

All heights in the Southern Nigeria Survey are referred to mean sea-level, and are classified as:—

Primary Heights.—Those determined by trigonometrical survey, topographical levels, and plane table with telescopic alidade.

Secondary Heights.—Determined by simultaneous comparison of aneroid barometers, as described in (b) to (i).

Tertiary Heights.—Those given by aneroid levels run between primary or secondary heights.

(b) *Aneroid work* is divided into two heads, viz.: (1) *Secondary Heights*—fixing the heights of certain points in the area under survey by means of simultaneous readings of two barometers, one at the point and one at the nearest topographical level; (2) *Tertiary Heights*—running what may be called "aneroid levels" between these fixed points.

(c) *Fixing Secondary Heights by Comparison of Aneroids.*—Certain convenient points from 5 to 12 miles apart are selected. These points are, for purposes of convenience, usually at villages or important road junctions. They should not, if possible, be more than 30 miles from the topographical level. A fine day should be selected. The system gives a probable error of 10 feet.

(d) The two aneroids are carefully compared. One is accepted as the standard, and the error of the other on that standard is noted. Great care should be exercised in this determination of index error. It should be noted that this index error is only relative for the two aneroids; it is not the true index error, but it is all that is required.

(e) One aneroid is then read at the nearest convenient point on the topographical level at the same moment as the other aneroid is read at the point of which the height is required. The hour, shade temperature, and reading in inches are booked.

Second and third sets of readings are taken at intervals of five minutes, chiefly to ensure correct reading of the aneroid. It will be noticed from the barometer wave chart that the most favourable time of day is between 8.30 and 10 a.m., and 2.30 and 4 p.m., as the wave is very small in those periods; but this is a refinement into which it is not usually necessary to enter, though it may be useful when watches are erratic. (Wave Chart, Table VIII., Appendix I.)

(f) Each set is then worked out independently (to ensure correct computation) in the barometer field book on Survey Form No. 21 and the mean result accepted. The result gives the difference in height between the two places.

Note.—C. practically does not affect the result in latitudes 0° to 10°. An error of ·01 inches in reading the aneroid produces an

error of about 10 feet. An error of 5° in t+t′ only produces an error of about 0·2 feet.

(g) Tables V. and VI. from *Close* are given in Appendix I., and are to be used for computations.

(h) In Table VI. the mean latitude may be taken if the latitude is high enough to affect the result.

(i) Example of computing difference of height between two points by Survey Form No. 21 :—

Log B	=	1·4732972
Log B′	=	1·4714091
D (Log B—Log B′)	=	·0018881
Log D	=	3·27602
A	=	4·83158
C	=	·00113
Log h	=	2·10873
h	=	128·4 ft.

B and B′ are the readings in inches of the aneroids at the lower and upper stations respectively, both having been corrected for index errors.

t and t′ are the Fahrenheit Thermometer readings at the lower and upper stations respectively.

Therm. at Upper Station	=	88°
Index error	=	0°
t	=	88°
Therm. at Lower Station	=	88°
Index error	=	0°
t′	=	88°
t+t′	=	176°

A is the number in Table V. corresponding to t+t′.

C is the number in Table VI. corresponding to the mean latitude.

The formula is Log D + A + C = Log difference of height in feet.

Name of Upper Station	ILARO	Lower Station	IGBOGILA
Bench Mark No. on	Church	Bench Mark No. on	P.S. (144′)
Approx. Lat.	7°	Approx. Lat.	7°
Barometer No.	4201	Barometer No.	4210
	″		″
Reading =	29·112	Reading =	29·737
Index error = ±	+ 0·496	Index error = ±	0
	″		″
B′	29·608	B =	29·737

Place, IGBOGILA.
Date, 14.11.10. (Signature) A. JONES, No. 2 Field Camp.

(j) In fixing secondary heights as described, the very greatest value attaches to the arrangements made by the camp officer. Besides carefully ascertaining the relative error of the aneroid, *and setting watches to the same time*, a very careful programme must be made that will allow reasonable time for the necessary journey of the assistant. If this programme is skilfully drawn up it should permit of the camp officer (stationed on the topographical level) and one assistant (travelling from place to place) fixing several heights in one day. A corresponding increase in the number of heights fixed will be obtained if more assistants are available.

A day may be set apart from these determination of heights, but the camp officer should make every effort to arrange a date convenient to the other work of the camp, so that time will not be wasted by the journeys. It will often be convenient for the camp officer to camp on the topographical level for a day or two to bring his work up to date, while his assistants travel about fixing heights.

(k) *Tertiary Heights by Aneroid Levels.*—Having fixed certain secondary heights as before described, aneroid levels are now run between them to fix tertiary heights on the forest tracks, and so obtain the form-lines.

These aneroid levels may be run either during the process of survey or afterwards, but *not*, unless under very exceptional circumstances, until the primary or secondary heights on which to close the level have been determined.

(l) *Barometer Wave.*—Before proceeding to describe the system of running aneroid levels, it is necessary to say a few words about the diurnal barometric wave in Southern Nigeria. This wave is very regular during the ordinary fine weather of the dry season *as regards the difference between maximum and minimum readings*, but by no means so regular as regards *the time of day at which these readings occur.*

The mean time of these readings also shifts as the months pass, and also for different districts, necessitating the construction of correction charts for each district and periodical revision.

The correction chart is shown in Table VIII. for every half hour in the day. It is not used when determining secondary heights, but for correcting readings on the altitude scale when running aneroid levels.

It is most important to bear in mind that the chart is independent of any setting of the altitude zero at sea-level, and that it is intended only for use between fixed heights by allowing the aneroid level to extend over several hours. It does not give absolute readings as a matter of course, although it may happen that it sometimes does so.

(m) *System of Running an Aneroid Level.*—This is best described by an example. We will suppose that an aneroid level is being run between *primary point* A (altitude 203 feet) and *secondary point* B (altitude 400 feet).

(n) The surveyor starts at A at 7 A.M. By the chart the correction for that hour is *plus* 33 feet. He sets his altitude scale so that the needle reads 203 *minus* 33, *i.e.* 170. The barometer is held vertical and tapped before reading. Before leaving the surveyor notes care-

fully in his field book what the zero of the altitude scale reads on the mercury scale, so that he can reset it if the ring slips. *This is most important*

(o) He then travels to B, running a compass survey on the way, and fixing the heights of his stations and any other desirable detail by noting the altitude reading and applying the correction for the time of day as given in the chart.

For example, at 9.30 A.M. his aneroid reads 150. The correction is *plus* 61, so the height is 211.

(p) At 1.30 P.M. he closes on B, and his aneroid reads 426. The correction from the chart is *minus* 36, so he makes the height 390. The real height is 400, so the close may be considered satisfactory and no adjustments are necessary.

(q) *Error and Limit.*—Should, however, his aneroid read, say, 476 on reaching B, thus giving the height as 440 feet, the error of 40 feet should be distributed at intervals along the traverse. Supposing there to be sixty stations, a correction of *minus* 10 feet might be applied to stations 1 to 15, of *minus* 20 feet to 16 to 30, etc.

If the error on closing is 50 feet or over, the aneroid level must be run again, and should an unsatisfactory close be again obtained, the secondary height should be checked.

(r) It will be perceived that the *essence of the use of the correction chart* lies in setting the altitude scale as described in (n) *on the day the survey is made.* The reason for this is that although, as stated in (l), the curve of the wave is uniform, yet it may be as much as 50 feet higher one day than it was the day before.

(s) When stopping at a station for half an hour or longer, the barometer must be read a second time before leaving the station; and always, when starting work in the morning, at the last station read at overnight. This is most important when bad weather or some other cause prevents the aneroid level being closed on a fixed point in one day, a thing which the camp officer should make every effort to avoid. If it should, however, be unavoidable, the height of the station last fixed overnight must be utilised for setting the barometer in the morning.

(t) *Levelling after Survey.*—In the example given in the foregoing subparagraphs, it was supposed that the aneroid level was run simultaneously with the compass survey.

Another way is to defer taking any aneroid readings until the completion of the survey of a block of, say, 60 to 100 square miles. Then to fix the secondary heights of, say, the corners of the block. Then to go round the block rapidly, reading the aneroid at all points of detail, and entering the results direct on the auxiliary sheet. Any adjustments necessary can be made in red.

In fact, the "contouring" is deferred until the completion of the block. This entails a certain loss of time, but is very convenient in those cases when the original survey was made in unsettled weather. There is a certain disadvantage attached to the fact that the original stations have disappeared, as sometimes points of detail are so far apart that several form-lines may cross the track between them. *Surveyors are warned to keep a careful eye on this should they contour after survey.* The points of crossing of the form-lines must be picked up by pacing from the nearest detail. The disadvantage, however,

disappears if trees are blazed at the tops and feet of all hills in the original survey, and noted on the auxiliary sheet.

(u) *Entries in Field Book.*—Aneroid heights are entered in the field book in feet in a circle, the correction being written underneath, but not applied. The time is also entered. *See* Specimen Field Books, paras. 118 to 121.

(v) *Handling the Aneroid.*—In all cases the aneroid must always be given a few minutes to settle down before reading, and must be gently but sharply tapped with the nail or pencil, not the flesh of the finger. It must be read held vertically by the ring, and every effort should be made to get rid of collimation by always getting the eye in the same relative position. If an aneroid is held vertically and a reading taken, then turned horizontal and then back to the vertical and a second reading taken, the readings will differ probably by 10 to 20 feet unless the aneroid is tapped again. Surveyors should therefore note the value of holding the aneroid steadily after the first tapping until the reading has been taken.

General Notes on Compass Traversing and Keeping Field Books.

117. (a) In para. 70 certain rules are given which apply to all field books, and the attention of surveyors is especially directed to para. 70 (c), (d), and (e). In the contents pages the surveyor will enter a list of the villages, rivers, permanent beacons, and blazed trees in the order of survey, and give the page on which they are to be found.

(b) At the beginning of every traverse the surveyor will paste Survey Form No. 26, on which he will enface the following information. (*Note.*—The words in italics are those printed on the form.)

I. (Primary, secondary, tertiary, rope or time.)
Compass Traverse from.....*to*.....
II. Compass No..... (State if any P.E.C., para. 115.)
c
III. C.M.V. at.....=.....*W* (*see page*).
(Here give the nearest place at which the C.M.V. was last determined, as in para. 115, and give the page and number of field book on which it was calculated, as in the example given at end of para. 115.)
IV. Measurement with..... (*Pace*= .)
(Here enter number and length of band, length of rope, nature of perambulator, or, if by pacing, state length of pace.)
V. Error in Band=.....*short* (*or long*).
VI. Barometer No.....
VII. Index Error=.....*feet.*
=.....*inches.*
VIII. Clinometer No.....*or Abney Level No*.....
IX. Traverse continued from Field Book No.....
X. Traverse continued in Field Book No.....

(c) As a field book may contain so many as thirty or forty minor traverses of only a few hundred yards' length branching off the main traverse, it will be sufficient if the full details are given for the

first of these traverses. In subsequent ones only the information under I., followed by a reference (such as "same details as on page....."), is required. It is unnecessary in those cases to paste in a whole form, but merely to write the information as above at the beginning of the traverse.

(d) When starting work daily write below the first station the date and time of starting, and when finishing give similar information. (*See* Specimen Book, para. 119.)

(e) The centre column is to be used for stations and measurements only. (*See* para. 118.)

The two columns on the left are for bearings and slopes.

The two columns on the right are for barometer, and temperature and time.

(f) *In the Bearing Column* enter the forward and reverse magnetic bearings, take the mean and deduct the compass magnetic variation. Enter the result *along* the page.

E.g.—Specimen Book, para. 119:—

	° ′
Mag. Bg from Station 82 to 83	= 133·30
Rev. Bg from Station 83 to 82	= 313·00
Mean	= 133·15
C.M.V.	= 13·30
Mean True Bearing	= 119·45

(g) *Slopes.*—The slope of the steel band is taken with an Abney or a clinometer, and is entered in the proper column, being written along the page.

Example.—In para. 118 there is a change of slope at 60′, 160′, and 210′. Opposite each of these points in the "slope column" a line is drawn, and the slope is entered between these lines, the band, for instance, sloping down 2° between station 19 and the point 60′, being level from 60′ to 160′, etc.

The correction for each slope is taken out of the slope tables (para. 111), added together, and the total correction entered in brackets in the slope column to the left of the measured length, as shown in para. 118.

(h) *Measurements.*—The actual reading of the steel band is entered in the field book, not the corrected length. The uncorrected length is sufficiently accurate for the field plotting, the corrected length being of use only when taking out co-ordinates. In very hilly country, when the correction for slope is plottable on the scale being used, the corrected length should be used in field plotting. Any error, also, in the length of the band should be noticed only when computing co-ordinates, unless, of course, it is so large as to be plottable, when it must be allowed for in the field plot.

For example, in para. 118, the length 232·7 is the actual reading of the long steel band in feet, and 3 chains 52·9 links is the actual reading of the short "chain" band used as a check. Errors of band and slope must be applied before computing.

Every time the steel band is laid an entry must be made in the centre column of the field book, to avoid the risk of missing out a complete length of the band.

Examples.—In para. 118 the long band is 200 feet long and was laid twice. In para. 119 the band is 100 feet long, and was laid four times. In para. 120 the 200-feet band was only laid once.

(i) Other measurements shown in the specimen field books require a certain amount of explanation.

In para 119.—312·1 is the reading of the steel band, 124 paces is the check on gross errors. The surveyor knows by experience that he paces 2½ feet, hence the entry " = 310'."

Similarly in para. 120.—Here the surveyor knows that he paces roughly thirty-five times to 100 feet.

In para. 121 the length of rope used is 203 yards. The surveyor started along the farm track from station 1 ; after going 60 paces the track stopped at the edge of a yam plantation, so the surveyor made this point station 2, and then turned to the left and surveyed around the plantation, his pacing being uncertain owing to bad ground. From 5 to 6 he found the ground quite open, and was able to stretch his rope straight, but in the other legs it will be seen that he considered there was a wind of about 1½ per cent., so he deducted 3 from every leg, and entered the measured length as 200.

At station 6 he was able to get a bearing to station 85 on the main traverse line, and to pace the distance, thus getting a check. He closed his surround by coming again to station 2, 20 paces from 7.

It should be noted that it is not necessary to survey many farms in this manner owing to their temporary nature, but only when they are very extensive. Farm surveys are chiefly useful when the country is hilly, as form-lines can then be determined. *See* 75 (e).

(j) *Barometer Readings* are entered as actually read in the second column from the right. When full readings are taken, as at station 20 (para. 118), the reading in inches, the temperature, and time are taken for future comparison with the camp barometer. The *reading* in feet is also entered in a circle for immediate use, the correction for the time of day being taken off the wave chart and shown under the circle. The corrected height of station 19 (para. 118), is, for example, 850 feet, and of station 20, 850 ft.

(k) *Offsets.*—All offsets to be given in feet, and to be written in the field book close against the point referred to, *e.g.*, para. 120.

Offsets to permanent objects, such as stone buildings, bridges, railway lines, telegraph poles, etc., should be measured with a 5-foot rod or a short length of tape, *but only when they are on primary compass traverses.* On all other occasions they can be put in by eye.

In the case of traverses along roads, it is not necessary to measure and enter offsets to the edges. The width of the road should be written along the page, as in paras. 118 to 121. When, however, the road enters a village an occasional offset to any permanent building on the road should be entered, as in para. 120.

(l) *Big Villages and Towns* are dealt with in para. 71 (c), but in carrying out the instructions therein contained the surveyor must remember that he is not executing a town survey. All that is intended is that the main streets, main buildings, main open spaces, and the roads leading out of the village should be shown in detail,

the remainder of the ground covered by houses, etc., being hatched. Care should also be taken to show the town wall, if one exists, or the approximate edge of the town, and, in the case of towns and villages in the forest belt, the edge of the clearing. Also *see* para. 74 (m) and (n).

When the surveyor reaches a town or large village the best thing he can do is to continue his main traverse right through it, and then to run a rapid rope and compass or a plane-table traverse around the perimeter, closed on the main traverse, noting where the various roads leading out of the towns cross it, and afterwards running down the most important of these with the plane table. *The less information that is put in the field book, and the more that is put on a good sized auxiliary sheet*, the more rapid will these rough town surveys be. The surveyor must guard against over detail and waste of time. In most cases measurement with a rope is sufficient. All first-, second-, and third-class roads, as in Ibadan, Oyo, etc., should be surveyed.

In the case of Small Villages, all necessary detail can quite well be shown in the traverse book, and the perimeter can be put in by eye. A rope traverse from the village to the water supply, if the latter is off the main traverse, should always be made.

Also *see* para. 83 (l).

(m) *Side Tracks and Blazed Trees.*—When a track branches off, or a stream crosses, the traverse line, a tree must be blazed with an arrow, and distinguishing number cut and painted into it, such mark to be entered in the field book. This is most important, as a week or longer may possibly elapse before the surveyor is able to undertake the survey of this track, and should he have to send his assistant to do it the mark will be invaluable as a guide. An example of a branch road is in para. 119, where an Iroko tree has been blazed with an arrow and the number "41." The entry "19 V.F.B. No. 4" signifies that the surveyor has entered full information about this track in "Village Field Book No. 4", under the reference number "19." Where no tracks lead off the road, or streams cross it, blazed trees should be at every half mile, and an especially large number must be left when *survey precedes contouring, as in para. 116* (t). *In this case a surveyor should be careful to leave blazed trees at the tops and feet of hills.*

In para. 119 it will be noticed that a tree has not been blazed at the farm track. This is on account of tree 41 being so close.

(n) The description and condition of the road along which the traverse runs; the nature of the country on each side (such as "hilly," "undulating," "mountainous," "flat," "swampy," "forest," etc.), the existence of farms and all other information likely to be useful, is to be entered along the page, as in the specimen forms of field book.

(o) *Tribal Boundaries.*—The point at which tribal boundaries cross the road will be marked as shown in para. 118, where the stream has been pointed out to the surveyor as the tribal boundary between the Egbas and the Budas. In this example the surveyor is supposed to have obtained the information laid down in para. 71 (a) XII., at the village of Rami, shown on the same specimen page. The entry "12 V. F. B., No. 1.," refers to the reference number "12" in

the surveyor's "Village Field Book, No. 1," where he should have entered such details as the name of the person who pointed out the boundary and any other information likely to be of use in helping to determine the general course of the boundary. This information may be obtainable on the spot and entered at the time, *see* (w).

(p) Road cleaning limits between villages are usually marked by the natives in some distinctive manner according to local custom, and these should always be noted as they may be useful in determining tribal boundaries. (*See* para. 119, near station 92.)

(q) *Village Names.*—These are thoroughly dealt with in paras. 69 and 71. The only entry necessary in the traverse field book is the name and reference number. *Example*: Zugu village in para. 120, the entry signifying that all details concerning this village are entered at the reference number "29" in "Village Field Book, No. 1."

(r) *Rivers.*—Similarly, river names are fully dealt with in para. 72 and it is only necessary to enter in the traverse field book their names and reference numbers to the river field books. *Example*: The *Sumu* stream in para. 118.

(s) It is very important, and also often difficult, to tell in which direction a stream flows when its bed is dry. The way in which grass, branches, etc., lie, often show this, and also, the silting of sand and earth over a stone or root, the upstream side being silted, and downstream side slightly undermined. After finding out the direction by these means, the surveyor must ask his guide; if there is a difference of opinion a query note must be made. Serious inconvenience is caused by carelessness in this respect, and if a surveyor cannot absolutely satisfy himself as to the direction, it is his duty to put the query note after the arrow head.

(t) *Co-ordinates.*—The corrected lengths and true bearings will be entered in the co-ordinate sheets and the co-ordinates extracted daily from either Boileau's, or Gurden's, or Chambers', Traverse Tables according to the class of traverse. The hour of day at which this should be done is left to the surveyor's discretion, and under ordinary circumstances there should be no arrears of this description. Carriers must on no account be kept idle during the day owing to the surveyor being occupied in computing. Surveyors will probably find it convenient at times to do half an hour's computing while the gang clears the traverse legs under the direction of the headman. *The rest day* can profitably be employed in computing, but the surveyor should not on that account allow arrears of co-ordinates to accumulate, for there will be several things to attend to on the rest day, such as transferring sketches from the auxiliary sheets to the field sheets, making up returns and accounts, conducting correspondence, paying the gang, etc.

(u) *Clearing.*—The amount of clearing to be done depends chiefly on the width of the roads. As clearing delays the survey it is advisable to do as little as possible. It is surprising how much can be done in lengthening legs by cutting off a branch, or levelling a small bush here and there, without wasting time. To cut wide avenues through the bush would be sheer waste of time in compass work. By following the path, with the assistance of a small amount of snipping and lopping, a surveyor will generally obtain legs from 200

to 400 feet long; on the other hand, it is as a rule injudicious to do too little clearing, as on bad paths this will lead to very short legs. A good broad road, with sights of from 200 to 600 feet, is the best that can be expected in dense forest, and is of course rare.

No minimum can actually be fixed for the length of legs. Surveyors must use their discretion.

The best results are obtained by the man who, by careful attention to this branch of his work, develops his "eye for country" so that he can range good lines by instinct. A series of very short legs is not only against accurate surveying, but increases computing work, one hundred "100-feet" legs requiring twice the time to compute as fifty "200-feet" legs.

Natives are very good at ranging if thoroughly taught to begin with, and a little time spent in teaching them amply repays the surveyor.

(v) *Overcrowding the Field Book.*—Surveyors are particularly cautioned against the tendency that usually exists to overcrowd field books.

If a large amount of detail exists between two stations there is no necessity to show it all on one page.

Occasionally it may happen that there is a particularly large amount of detail between two stations, and, at the same time, a vexatious number of changes of slope, or perhaps a triangulation or a subtense measurement across a river. In these cases there is no reason why the bearings, slopes, and measurement of the leg should not be put on one page and the detail on the next.

(w) The traverse entries can always be suspended temporarily by drawing a line across the page (as in para. 118) and then entering notes, drawing another line, and continuing the traverse entries. This course is particularly recommended.

Starting and Closing Points of Compass Traverses.

122. (a) In para. 100 (d) it is laid down that compass traverses must always begin and end at "fixed points" on the framework, or on points already determined by a compass traverse of higher class.

(b) The last-named condition applies chiefly to block surveys. When a compass framework has been surveyed and closed on the main framework to supplement the latter, the blocks so formed are surveyed in detail by the more rapid forms of compass traverses, which may start at, and close on, points on the compass framework.

(c) *In the forest country*, the fixed points defined in para. 6 (u) are practically all on the theodolite framework, on which any point marked by a beacon or bench mark may be accepted as a starting or closing point.

Similarly, any point on the compass framework mentioned in (b) may be accepted as a starting or closing point if it is marked by a survey beacon, bench mark, or marked tree.

(d) In triangulated country under plane-table survey, compass traverses are, on the few occasions they are made use of, started and ended at a plane-table fixing as soon as one can be determined, or on any convenient trigonometrical point or plane-table trigonometrical point.

SPECIMEN FIELD BOOK

PRIMARY COMPASS TRAVERSE

(Double Chaining with 200' and 66' bands)

RAMI VILLAGE (12 VFB N°9)

1·10
55
1 85
018
1/666

278°50'

3

21
110 0
1/65 4

Level

81°43'

82 5

98°40'

20

820 12 NOON

Stone House

14

Station 20 is Survey Beacon SNS 92, covered with earth mound

140° M 72

227° M 114

Mango Tree 13

2 327
1·1635
3 4905
·0349
5/5254
1ks

Ch

267°15' (0 1)

Edge of 20 Forest

232 7
3c 52 9 1ks

29 21 83°
830 11 5 A M
+40

Level +1°30' +2°15'

81°10' – 17°02' 70°68

Track 5 wide

210
200
180
160

300 Bicycles

YAMS

EGBAS

Tribal Boundary (12 VFB N°)

BUDUS

Hammock

90
60

Fair for 27 SUMU 8TH

42 RFB N°3

Forest

Dense

57°05 -2°

19

810 10 55 A M
+40

Mag Bearing
Mean True Bearing
Slope & Corr^n

Stations & Chaining

Bar. Reading & Correction

Temperature & Time

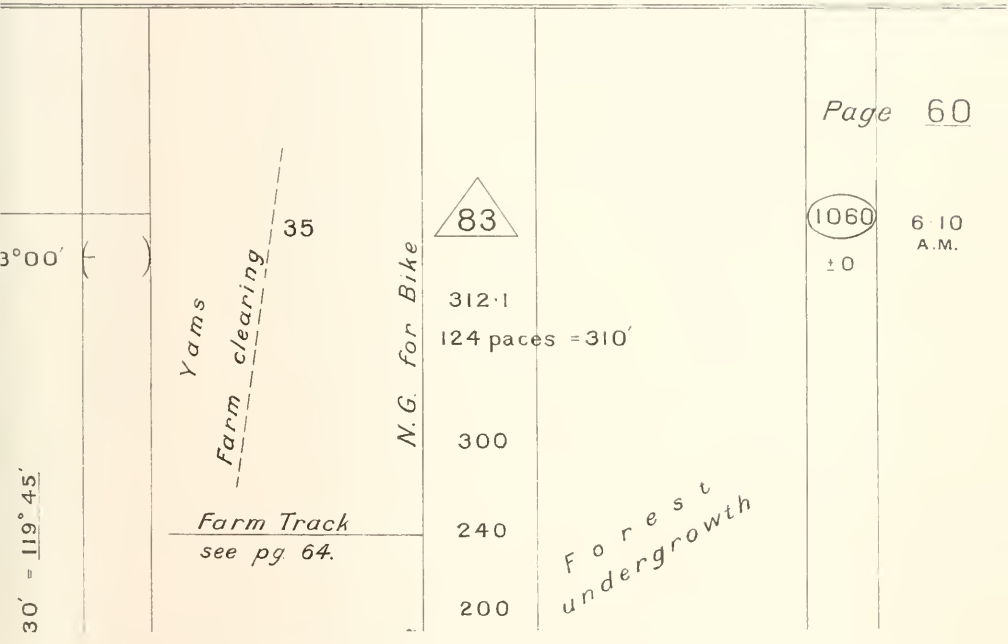
SPECIMEN FIELD BOOK

SECONDARY AND TERTIARY COMPASS.

TRAVERSES WITH 100′ BAND

(Single Chaining)

(A Continuation of this example is given in para 121)



SPECIMEN FIELD BOOK---

SECONDARY AND TERTIARY COMPASS TRAVERSES WITH 100' BAND

(Single Chaining)

(A Continuation of this example is given in para 121)

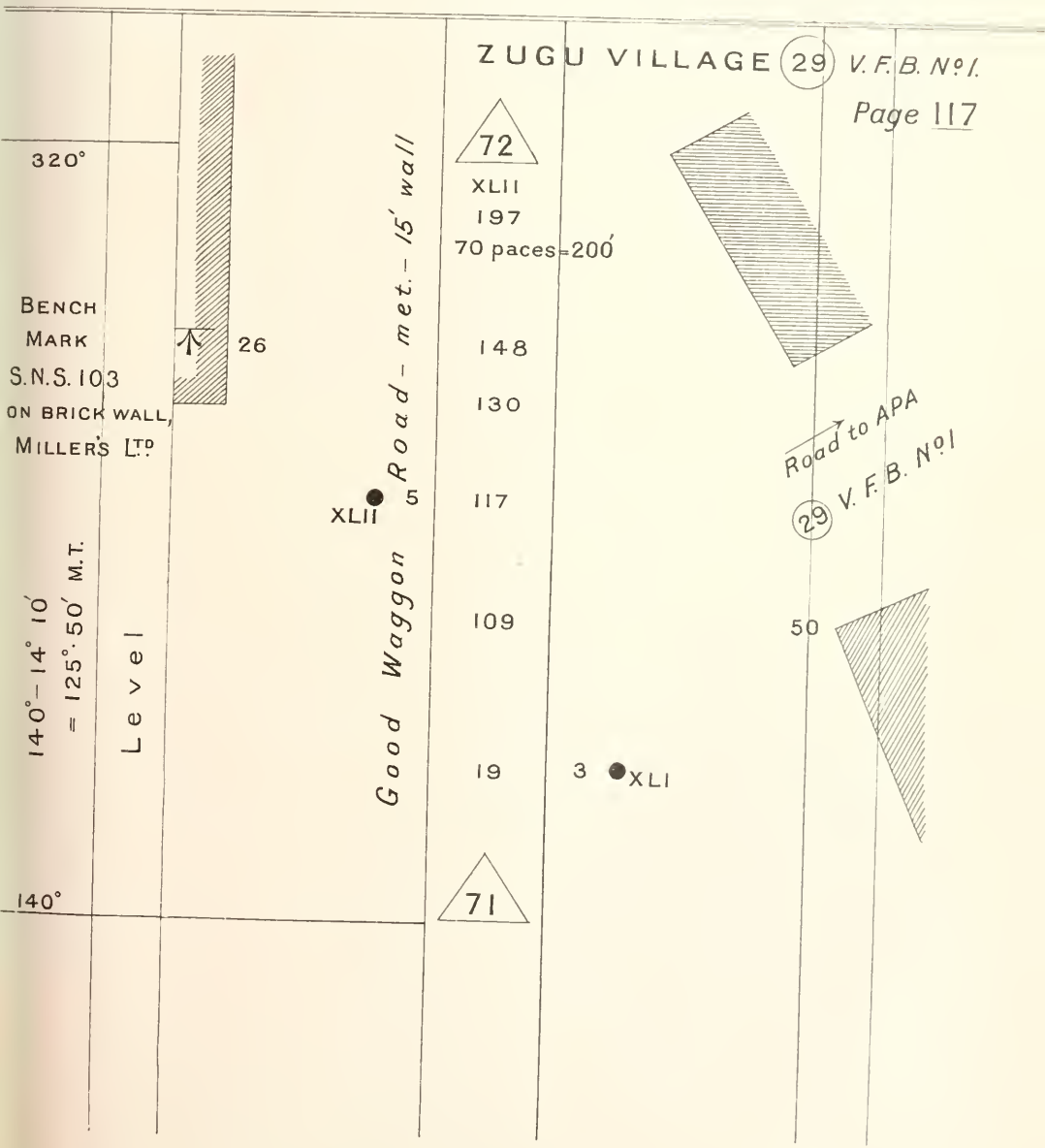
SPECIMEN FIELD BOOK.

TERTIARY COMPASS TRAVERSE

WITH 200′ BAND

(Single Chaining.)

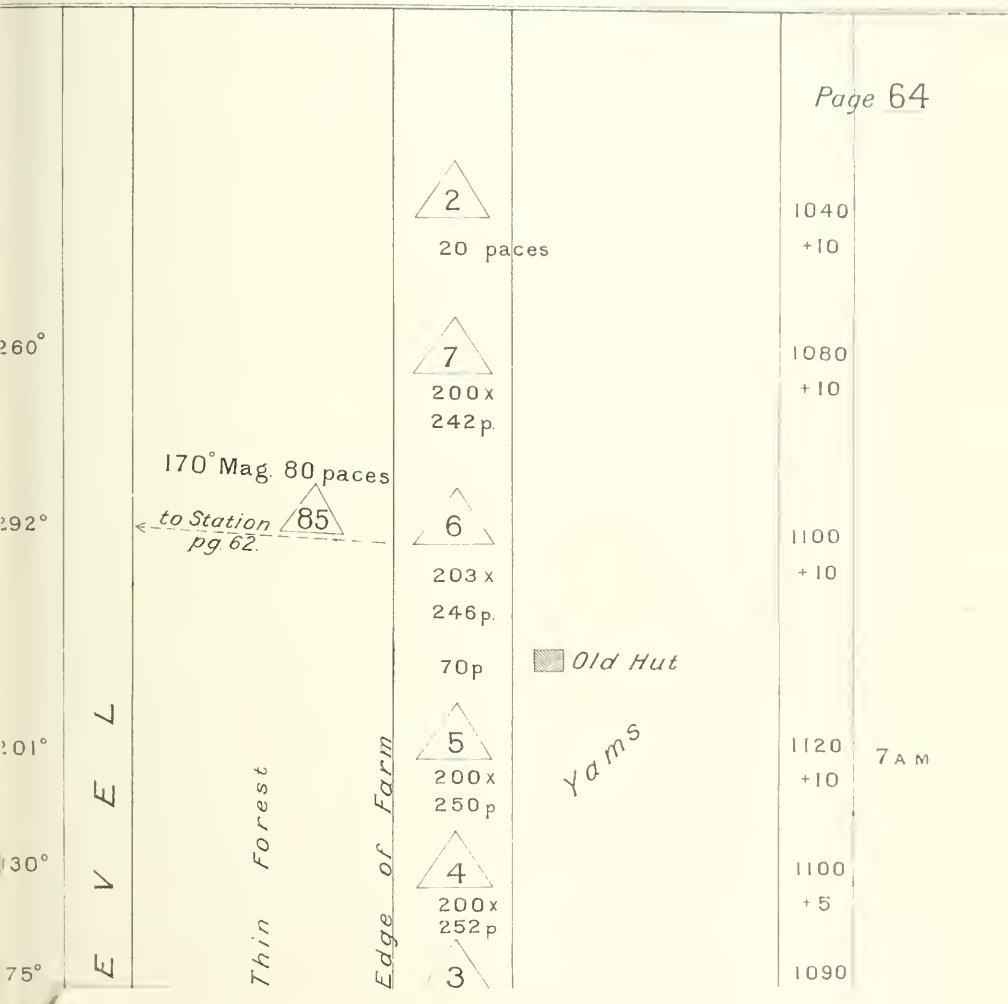
This is an example of a compass traverse of a line of Levels, no barometer readings required. The Roman figures represent the Level Stations



SPECIMEN FIELD BOOK

ROPE TRAVERSE ROUND A FARM

(SEE FIELD BOOK, PARA. 119.)



SPECIMEN FIELD BOOK

ROPE TRAVERSE ROUND A FARM

(SEE FIELD BOOK, PARA 119)

Page 64

		2		1040
		20 paces		+10
260°		7		1080
		200x		+10
		242p		
	170° Mag 80 paces			
92°	to Station 85 pg 62	6		1100
		203x		+10
		246p		
		70p	Old Hut	
		5	Yams	1120 7 A M
		200x		+10
		250p		
		4		1100
		200x		+5
		252p		
75°		3		1090
		200x		+5
		248p		
350°		2	Edge of clearing	1070
		60p		+5
80°		1	82 +240'	1050 6 30 A M
				+0

LEVEL

Thin forest

Edge of farm

Farm Track

ROPE TRAVERSE FROM STATION (82)
PLUS 240 IN THIS BOOK, PAGE 60
6 30 A M 18 11 10 ROPE 203x TO BE PLOTTED
AS 200x EXCEPT WHERE STATED

111

(e) In the triangulated country described in para. 100 (b), compass surveys are very much used. Here the starting and closing points may consist of every variety of fixed point, ranging from a trigonometrical station to a plane-table fixing, or may consist of points on the compass framework surveyed to supplement the trigonometrical framework.

(f) *In all cases surveyors must rigorously observe the rule* that full descriptions of the starting and closing points of all compass traverses are given at the beginning and end of the field-book entries, or, if no field books are used, on the auxiliary sheets.

CHAPTER IV.

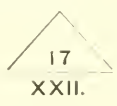
LEVELLING AND FIELD ASTRONOMY.

Topographical Levelling.

130. The system of levelling adopted in Southern Nigeria in forming the vertical framework of the map in the forest and mangrove belts is an effort to compromise between accuracy and the cost of running a very high-class geodetic level through dense bush where extensive clearing is necessary to obtain rays of over 300 feet. This system, which may be styled topographical levelling, allows curvature, refraction and instrumental errors to be ignored. The correction for curvature in feet is two-thirds of the square of the distance in miles, *i.e.*, $\frac{1}{2}$ inch in a ray of a $\frac{1}{4}$ mile, consequently, the rays being seldom more than 200 feet, the correction for curvature is not often necessary.

Compass Traverse of Line of Levels.

131. Unless instructions to the contrary are given, a compass traverse of the topographical level will form part of the levelling camp's work, but will be conducted entirely separately to the levelling work. The traverse stations need not be the same as the levelling stations, though they often are, but the traverser must take care to survey all the stations used by the leveller, placing them on his map and entering them in his field book. Confusion is prevented by the fact that all levelling stations are given in Roman numbers by the leveller, these numbers being adhered to by the traverser. Where a traverse and levelling station are identical, say No. 17 Traverse Station and No. XXII. Levelling Station, the traverser enters the traverse station number in the centre column and the levelling station number below it, *e.g.*,



See Specimen Field Book, para. 120. Compass traverses of a line of levels may be either primary, secondary or tertiary, according to the instructions issued.

Levelling Camp.

132. Details of the composition and loads of a levelling camp are given in para. 51 (e) and para. 52, Tables IX. to XI. The duties of the camp officer are similar in principle to those of a field-camp officer (paras. 65 and 66).

133. The description of the topographical levelling given here should be followed with the aid of the Level Diagram in Fig. 14, and the Form of Field Book—Levelling.

(a) *Odd Numbers*, viz., I., III., V., etc., are given to all stations on the line; *letters* (A, B, etc.), to all intermediate points the heights of which happen to be particularly desired; even numbers (II., IV., VI., etc.), to stations where the instrument (a Dumpy, Y, Cook or Stanley Level), is set up.

Description of Levelling System.

(b) Set up and adjust the instrument at II., which *must be half way* between Stations I. and III., but which need not be *on* the line I.-III. This gives a great advantage in running levels along a winding track, as II. may be selected at the turn of the path. Care must be taken to mark roughly the point II. with a short numbered picket for the traverser's information.

(c) The height of I. is assumed to be 100 in this example. It is entered in column g, *see* Field Book Form. If the height of I. is known it is of course taken.

FORM OF FIELD BOOK—LEVELLING.

a *Number of Station or of Intermediate Picket.*	b *Back Reading to Odd Number Stations.*	c *Intermediate Reading, or at Even Number Stations Height of Instrument above Ground.*	d *Forward Readings to Odd Number Stations.*	e *Rise—b – c or b – d.*	f *Fall—c – b or d – b.*	g *Reduced Level of Stations or Picket.*	h *Horizontal Distance in Feet from First Station.*	i *Remarks.*
I.	5·98 6·28	...	...	...	...	*100·00	0	*Assumed.
II.	...	4·20	...	(1·78)	...	101·78	35	
A	...	4·41 4·71	...	(1·57)	...	101·57	70	
III.	0·61 0·91	...	9·60 9·90	...	3·62	96·38	500	
IV.	...	3·61	...	...	3·00	93·38	...	
V.	...	...	6·81 7·11	...	6·20	90·18	900	
Totals	13·78		33·42	0·00	9·82	Height	of I =	100·00
			13·78		0·00	Height	of V =	90·18
			2)19·64					
			9·82		9·82			9·82

When single readings only are made the total difference at the foot of column d is not divided by 2.

(d) Intersect both the front and back of the staff at I. and enter the results (5·98 and 6·28) in column b.

The readings are always to be taken on the front and back of the staff. These will usually differ slightly, but should do so by the same amount at each station, thus satisfying the leveller that he has not made an error in reading. *The reading of the front only* is used in computing the height of the forward station. The double reading is used in the mathematical checking. *See* subpara (j).

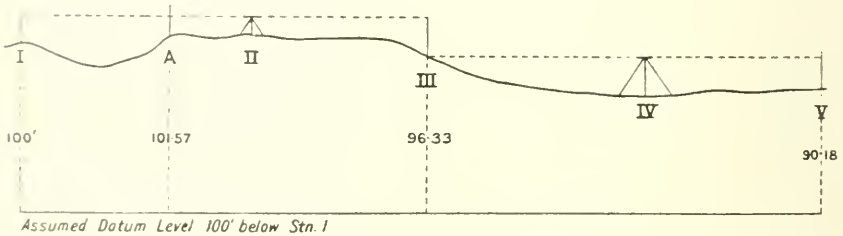
The staff must be held vertical by means of a plumbob, or else swayed slightly backwards and forwards in the plane of the leveller, who is able to check any tendency of the staff to lean sideways by his vertical wire and signals to the staff man.

The front of the staff should be coloured a light red or green and *should always be read first.*

(e) Now intersect the staff at III., front and back as before. Enter the result (9·60 and 9·90) in column d, and the difference between b and d in either column e or f, according to whether the difference is a rise or fall. If the back reading is greater than the

Fig.14

Level Diagram



forward reading then the difference is a rise; if the back reading is the smaller the difference is a fall.

In this case d − b = 3·62 and is entered in column f as a fall.

Deduct 3·62 from the level of I., and the result is 96·38, the level of III. Enter it in column g.

(f) As can be seen from the foregoing, *the level of II. is not used in determining the level of III. and need not be taken unless specially required.* It is the exception to take it. If it is required measure the height of the horizontal wire above the ground (4·20) and enter it in column c. Then b − c = 1·78, which must be entered *in brackets* in column e, and added to level of I. to get the level of II., *i.e.*, 101·78.

(g) The level of any intermediate point A, on or off the line of traverse, may be determined in the same way as III. was determined.

In this case the staff at A reads 4·41 and 4·71. The difference between b and c is thus 5·98 − 4·41 = 1·57, which is also entered in brackets, and, as b is greater than c, added to the level of I. to get the level of A.

In the case of these intermediate points, as well as in the case of

even-numbered stations, the rise and fall are entered in brackets, as they are not used in the mathematical check made later on.

An intermediate point is chiefly used to get a bench mark off the line of traverse and, unless it is the same distance from II. as is I., the result is not reliable. Care must therefore be taken to arrange suitable distances when the intermediate point is used as a bench mark.

(h) Now move the instrument to IV., half way between III. and V. Read the front and back of the staff at III., and again at V. take the difference (*i.e.*, 0·61 − 6·81 = 6·20), and deduct it from the level of III. (96·38 − 6·20 = 90·18), and thus obtain the level of V.

(i) *Beacons and Bench Marks.*—The process is carried on as above until the next bench mark or survey beacon is reached. If it happens that the route has not been previously surveyed and has no beacons on it, a bench mark must be made or a survey beacon put in (para. 83) at every village, important cross-road, railway or stream crossing, or if none such occur at every three miles. Bench marks or beacons should always be off the road. This can usually be managed by diverting the line so as to get a station off the road, but sometimes it may be necessary to make it at an intermediate point, *see* (g).

(j) *Mathematical Check.*—At the bench mark or beacon the levels are checked. In the example the check is made for explanatory purposes at Station V. The difference between the total of the readings of the back stations and the total of the readings of the forward stations (*i.e.*, 13·78 − 33·42 = 19·64) is divided by 2. This gives −9·82, which should be the same as the difference between the reduced levels of I. and V. in column g. A further mathematical check is supplied at every station by adding up the rise and fall columns *for the odd-numbered stations only*, omitting those in brackets belonging to even-numbered stations and intermediate points.

(k) As regards length of sights, it is advisable not to read more than 300 feet with a 14-inch level, or more than 250 feet with a 10-inch level.

(l) *All* stations and intermediate points should be marked by short pickets, numbered, for the traverser. A good way to get the even-numbered stations half way between the odd numbers is by means of a cord stretched from I. to III., then the end at I. is carried to III., the bight of the cord giving the half-way mark *on a straight line* between I. and III.; but, as usually happens, II. is at a bend in the track, and in this case the cord (or a steel band) is stretched from I. to II., and then carried forward to get III.

(m) Lines of topographical levels will be checked by closing surrounds, instructions for which will be issued from Headquarters.

General Remarks on Field Astronomy.

134. (a) Field astronomy, as practised in the Southern Nigeria Survey, resolves itself into two main branches, viz.:—

I. *Special Astronomical Work*, such as latitude observations with the zenith telescope, and time observations with the transit instrument, for use in telegraphic determination of longitude. Instructions for this work is issued in survey circulars.

II. *Ordinary Astronomical Work*, in constant use by field camps, and which usually consists of latitude observations with a probable

error of 3″ for the adjustment of compass traverses in the forest belt; time observations, for use with the foregoing; and azimuth observations, for use in theodolite traverse and in determining magnetic variation.

(b) It is not proposed to enter fully here into either the theory or practice of field astronomy. Close's *Text Book of Topographical Surveying* (Edition 1905), Chapter XIV., and the *School of Military Engineering Notes on Astronomy* (Edition 1908) are adopted as the astronomical text books of the Southern Nigeria Survey, and the School of Military Engineering Angle Books and Astronomical Forms for booking and computations. The procedure therein laid down will be strictly adhered to both as regards the system of observation and booking, and the method of computing. In the paragraphs which follow the attention of officers is drawn to the methods to be followed by field camps and the forms to be used.

(c) Astronomical forms are issued bound in book form, and must be carefully completed in all respects.

(d) The use of the elements in the *Nautical Almanac* is fully explained in *Close*, p. 138, *et. seq.*

(e) Hints on the use of the theodolite in field astronomy are given in *Close*, p. 141.

Field Camp Time Observations.

135. (a) Determination of time by field camps to within half a second (7·5″ of arc) is only necessary in the case of latitude observations. For azimuth observations it is sufficient if the time is right within fifteen minutes for sun observations, and is not required at all for star azimuths.

(b) Time observations generally are dealt with in *Close*, pp. 142-145, and *School of Military Engineering Notes*, 1908, pp. 11-22.

(c) *Time by Altitude of Sun.*—Take two sets of observations, each of four altitudes, as follows. If there are clouds occasionally obscuring the sun observe :—

One set
- Face left, upper limb.
- Face right, lower limb.
- Face right, upper limb.
- Face left, lower limb.

If the day is clear, to avoid changing face twice observe upper and lower limbs with face left, and then with face right.

Follow the procedure in *School of Military Engineering Notes*, 1908, pp. 12-14.

Book as in *School of Military Engineering Notes*, Appendix I., or *Close*, p. 163.

Compute on School of Military Engineering Astronomical Form 1 (*School of Military Engineering Notes*, Appendix II., or *Close*, p. 171).

Times by the sun are not recommended in the Tropics owing to the danger of sunstroke. The observations must be made between 7.30 and 9 a.m., or 3 and 4.30 p.m.

(d) *Time by Altitude of East and West Stars.*—One pair of one east and one west star should be sufficient, but it is safer to observe two pairs.

Four altitudes of each star—face left, face right, face right, face left. See *School of Military Engineering Notes*, pp. 20-22.

Book as in Appendices III. and V., *School of Military Engineering Notes*, or *Close*, p. 164.

Compute on School of Military Engineering Astronomical Form 2 (*School of Military Engineering Notes*, Appendices IV. and VI., or *Close*, p. 173).

(e) *Do not observe for azimuth at the same time as for time* as inaccuracies arise if an attempt is made to intersect sun or star with both horizontal and vertical wires.

136. (a) General notes on azimuth are given in *Close*, pp. 147-149, and in *School of Military Engineering Notes*, pp. 24-29.

Field Camp Azimuths.

(b) *Sun azimuths* should be rarely taken, and directions are given in para. 165 (a).

The method described in *School of Military Engineering Notes*, 1908, p. 25, is to be followed.

Book as in *School of Military Engineering Notes*, Appendix VII., or *Close*, p. 165.

Computation on School of Military Engineering Astronomical Form 3 (*School of Military Engineering Notes*, Appendix VIII., or *Close*, p. 175).

Three sets of observations, each consisting of two measurements of the angle between sun and referring object to be taken.

(c) Star azimuths are far more accurate.

Observations on two pairs of east and west stars are sufficient, but it is safer to take them on three pairs. *See* 165 (b).

The observation to each star consists in measuring the horizontal angle between it and the referring object twice.

Book as in *School of Military Engineering Notes*, Appendix IX.

Compute on School of Military Engineering Astronomical Form 3 (*School of Military Engineering Notes*, Appendix X).

(d) The error of observed azimuths for traverse work is dealt with in para. 165 (a) and (c).

(e) In practice it is found that within about 10° of the equator stars within a zenith distance of 25° give good results if worked in pairs that balance.

(f) Remarks on referring objects for azimuth observations are given in para. 165 (e) and (f).

137. (a) General remarks on latitude observations, the selection of stars, and preparation of programme are given in *Close*, pp. 151-156, and in *School of Military Engineering Notes*, 1908, pp. 36-44. Particular attention is drawn to the necessity of making a careful programme.

Field Camp Latitudes.

(b) Latitudes must always be observed to three pairs of north and south stars; each pair should be well balanced; no star should be of less altitude than 35° or greater than 65°. Latitudes must be immediately preceded or followed by time observations.

(c) Latitudes will be computed from at least eight circum-meridian altitudes of each star, four on each side of the meridian. Start with one altitude, then change face and observe two altitudes on each

face alternately until sufficient altitudes have been obtained when the star is falling.

Book as in *School of Military Engineering Notes*, Appendix XIII., or *Close*, p. 166.

Compute on School of Military Engineering Astronomical Form 4 (*School of Military Engineering Notes*, Appendix XIV., or *Close*, p. 177).

(d) Latitudes by circum-meridian altitudes of the sun are not sufficiently reliable, and should not be used except for use in the determination of time and azimuths.

(e) The probable error of the arithmetic mean of the six sets of observations should not exceed 1·5″. For method of obtaining probable error *see* para 165 (c).

QUADRUPOD COCKSHY

THE STAFF S.N. SURVEY. 1910-11.

IN CAMP

CANOE TRAVERSE.

CHAPTER V.

THEODOLITE TRAVERSES.

160 (a). THEODOLITE traverses are used to form the horizontal framework of the standard map in the forest and mangrove belts in Southern Nigeria, where triangulation is impossible. The framework is formed by running the traverses between points whose latitudes have been determined astronomically and longitudes fixed by telegraph.

General Remarks.

(b) These *ruling points*, as they may be called, should be from 50 to 60 miles apart in latitude and longitude. There is no advantage to be gained by reducing these distances, as the following considerations will show. *Note.*—The trigonometrical point where a traverse joins the trigonometrical survey is a ruling point.

"The chief error in latitude observations is due to the inclination of the plumbob, which can only be inferred after laborious and expensive geodetic operations. It has, in extreme cases, been known to amount to over 30″ (giving a displacement of about 3000 ft.), and may, in an unknown country, be assumed to average about 2.″ If, therefore, one assumes the local attraction to be 2″ between two points, and that the error of the observed latitude of each point is 0·5″, we may expect an error from this cause of $\sqrt{\cdot 25 + \cdot 25 + 4\cdot 0 + 4\cdot 0} = 2\cdot 9''$, or about 300 feet. If we determine that the error from this cause shall not be more than 1 : 10,000, then the length of the line should be 10,000 × 300 feet, or 600 miles. If the error is to be 1 : 1000, the points should be 60 miles apart. To reduce the distance much farther would be to introduce errors larger than those due to the chaining errors of a traverse, hence the minimum distance apart of latitude stations should be, say, 50 miles, and this may be increased with safety. By the same reasoning, it is easy to see that it is waste of time to observe very refined latitudes for this survey, and it may be taken that a latitude within 0·5″ is sufficiently good.

"Longitude is affected by local attraction in the same way. A telegraphic determination with field apparatus may be expected to be correct within 0·2″ of time or 3″ of arc. This, and the local attraction (on the same reasoning as above), render it desirable to have at least 50 statute miles of longitude between the longitude stations." (From a Pamphlet by Lt.-Col. Close.)

(c) At all times, and especially when no telegraph is available for determining the longitudes of ruling points, the traverses must be

checked by running them so as to form closed figures as nearly triangular in shape as possible.

(d) Also, if it can possibly be avoided, no traverse should run generally east and west, although there is no objection to this for a short length. An east and west traverse cannot be checked by an observed latitude.

(e) Although a maximum error of 1 : 2000 only is aimed at, the system on which the primary theodolite traverses are run is so complete, and the instruments (5″ Troughton and Simms' "micrometer-microscope") so excellent, that the error probably lies between 1 : 2500 and 1 : 3000. (This was the average error in the Gold Coast Survey after the surveyors had gained experience and the best system had been adopted.)

The wear and tear of the climate on the surveyor, however, and the shortness of legs (*i.e.*, rays) due to the dense forest, have to be taken into account, and it is therefore considered safer to allow for an error of 1 : 1000. If this were not the case, and an error of, say, 1 : 2500 allowed, the ruling points laid down in (b) would be too close together to form an efficient check on the traverse. As it is, the traverse amplitudes, should the figure close well, are generally more to be relied on than the astronomical amplitudes.

Definition. Traverse Amplitude. — The distance (latitude and departure) between two points by the co-ordinates of the traverse, reduced to degrees, minutes, and seconds. *Astronomical Amplitude.*— The difference between the observed latitudes or telegraphic longitudes of the two points.

The system is adopted, however, of taking the mean between the observed latitude of any point, B, and its latitude as computed from a traverse joining it to a fixed point, A, by Survey Form No. 32. Similarly, the mean between the telegraphic and traverse longitudes of B is taken.

Whatever system of adjustment is adopted, it must always be remembered that *the position of a trigonometrical ruling point is to be taken as correct, and the traverse adjusted to it.*

A more rigorous method of adjustment is described in *Close*, Chapter XVII.

Remarks on the adjustment of traverses are given in para. 188.

(f) *Sections.*—The traverses are divided into sections. A section usually consists of the length of traverse lying between two ruling points. It is given a reference number, and is divided into subsections, usually between azimuth stations. Reference numbers of sections are given in Roman numbers; of subsections in letters, *e.g.*, XII. (b).

Outline of System and Party Required.

161. (a) There are eleven processes in carrying out the theodolite traverse system adopted in Southern Nigeria. A detailed description of each is given later. The system has been criticised as being, in certain respects, too painstaking in view of the degree of accuracy (1 : 1000) aimed at. It should, however, not be forgotten that in a country where climate and topographical features are both against good work, too great care cannot be taken to guard against the mistakes that mere man under such conditions is liable to make.

These processes are not given in the order in which they are carried out.

1st Process.—Clearing. Starting at 1, the traverse legs are cleared through the forest for about 5 miles until 65 is reached. (Paras. 162, 163.)

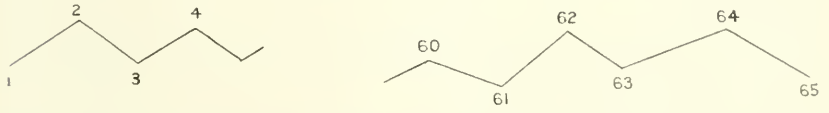
2nd Process.—Azimuths. The azimuths of 1–2 and of 64–65 are observed. (Paras. 164, 165.)

3rd Process.—Angular Measurements. The included angles at 2, 3, 4, 5,.....62, 63, and 64 are measured, and the vertical angles read. (Para. 166.)

4th Process.—False Bearings. Knowing the azimuth of 1–2 and the angles 2, 3, 4, etc., the bearings of the legs 2–3, 3–4, 63–64, 64–65, can be deduced. As slight errors in angular measurements are to be expected these deduced bearings contain errors, so they are called "false bearings." (Paras. 167 XVIII., and 170.)

5th process.—Closing Error. The azimuth of true bearing of 64–65 is observed, and the difference between it and the false bearing of 64–65 is the "closing error." (Para. 170.)

TRAVERSE DIAGRAM.



6th Process.—Distribution of Error. Suppose the closing error to be 63″. Apply this equally among the legs, 1″ to 2–3, 2″ to 3–4, 3″ to 4–5,.....61″ to 62–63, 62″ to 63–64, 63″ to 64–65. The true bearing of the legs is thus obtained. (Para. 170.)

7th Process.—Measuring the Legs. (Para. 171.)

8th Process.—Survey Beacons. Erecting beacons at 1, 2, 64, and 65 to preserve the azimuths, para. 165 (c), and at any other points of importance, para. 83.

9th Process.—Topographical Detail. Keeping a protractor plot of the traverse, leg by leg, on auxiliary sheet, and transferring to field sheet. (Para. 172.)

10th Process.—Computing Co-ordinates of Stations 2 to 65. Referred to station 1 as origin. (Para. 173.)

11th Process.—Computing Traverse Latitude and Longitude of 65. By Survey Form No. 32.

12th Process.—Sending Results to Headquarters.

(b) Theodolite traverses may or may not form part of the work of the ordinary field camp, but special parties are usually told off for the work. The detail of the composition of a field camp on theodolite traverse framework is given in paras. 51 (d) and 52, Tables XII. XIII., and XIV.

162. (a) The remarks on clearing given in para. 117 (u) for compass traverses apply generally to theodolite traverses, but an effort should be made to obtain longer legs. The rate of advance of the traverse depends both on the *amount of clearing* that can be done in

the day and on the *length of the legs*, the latter factor being worthy of consideration in this respect, as the number of stations at which a surveyor can "set up" during the day is limited owing to the strain of observing on the eyes.

General Remarks on Clearing.

(b) Legs should be as long as possible, but, except when traversing along the beach, the surveyor will find that he can seldom get longer rays than about 300 to 400 feet without unduly delaying the advance of the traverse by extensive clearing.

(c) In the denser parts of the Gold Coast and Ashanti forests it was found that, in high-class theodolite traverses, an *average length* of leg of about 300 feet only was obtainable. To obtain this average length twenty men took about eight hours' work to clear about twenty-two legs, or 1¼ miles a day. If an endeavour was made to obtain legs of 400 feet *average length*, the clearing at once dropped to a mile a day. The principle generally adopted was to clear the leg until an unusually large tree was met, and then to change the direction of the traverse.

(d) It was further found that about twenty-five stations was a good average day's work for the surveyor. More than that tired his eyes and led to inaccuracy in observing, carelessness in booking and chaining, and an undue accumulation of co-ordinates to work out on reaching camp.

(e) The foregoing remarks apply chiefly to traversing in very dense forest. As the country opens out more, the rate of advance and length of legs naturally increase.

(f) As the accuracy of the traverse also increases with the length of leg, it is evident, in view of what has been said, that surveyors should take great pains to train their headmen in ranging and to organise their gangs so as to carry out the work expeditiously.

163. (a) The following system has been found by experience to be good, and is recommended as a guide to surveyors. *See* para. 52, Table XIII. The gang is divided up into two parties of ten men each, each party under a headman or competent ranger, and composed as under:—

System of Clearing Legs and Making Stations.

Two Matchet Men, the best in the gang, leading, and slashing a *ray* through the undergrowth to enable the headman, standing at the back station, to get a glimpse of the red and white banderole held at the end of the ray.

One Banderole Boy.—He carries a matchet and shifts his banderole forward as the ray advances.

Note.—Sometimes the headman will find it more convenient to advance with the banderole boy. By so doing he maintains more control over his gang.

Three Matchet Men and Three Axemen widening and clearing up the ray until the leg is sufficiently wide for chaining. *The leg should only be just wide enough* for the chainmen to walk along; natives are generally inclined to make it far too wide, and thus to waste time and labour. Cleaning up the surface of the ground is also usually overdone by natives. Axemen should always carry a matchet as well as an axe, and should not stand idle when there are no trees to fell.

One Picket Man, with matchet, hand axe, small saw, and maul,

who cuts pickets from 3 to 4 inches in diameter and about 4 feet 6 inches long. Pointing the end, he drives the picket about 18 inches into the ground at the banderole to form the station; cuts an inch or so off the top with the saw to get a flat surface, shaves a small patch of the bark off the picket so that it can be numbered, and gives it a final tap in case the sawing should have loosened it in the ground.

(b) *Height of Picket.*—One of the most exasperating things that can happen to the traverser is to find, on reaching the forward station, that the picket is too high for him to set up his theodolite. This usually happens when the ground at the station is soft, or very uneven. On the other hand, the higher the picket the less do inequalities in the ground between the stations interfere with observing. Headmen should therefore be carefully trained to see to the following things before leaving the station:—

I. With their eye at the height at which the theodolite will probably be, they must look along the leg from both stations to make sure that they can see the top of the picket at the other end, and that no hanging vines interfere with the ray.

II. That the picket is not too high for the theodolite to be set up over it, bearing in mind that room must be left for the plumbob.

Note.—Surveyors will find that they will save themselves endless trouble and annoyance if the headman carries a "dummy theodolite," which is easily constructed of bamboo, with a real or makeshift plumbob.

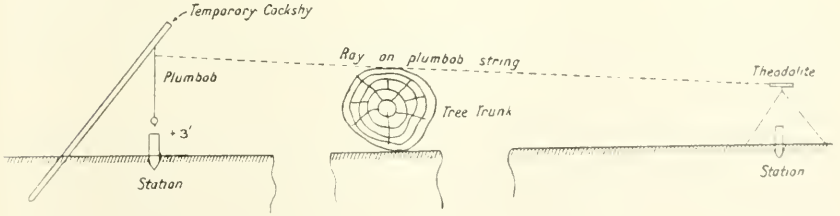
(c) *Starting Work.*—The two parties mentioned in (a) should start clearing about 1 to 3 miles apart, and both work towards each other. This distance depends on the density of the forest. When the parties meet, work stops for the day. The obvious advantage of this system need not be dilated on.

Work should be so arranged that, when the surveyor stops observing for the day, he has several cleared legs in front of him on which to start work the next morning.

(d) *Big Trees.*—When big trees are encountered on the line of traverse it is waste of time to cut them down. A station should be made, and the next leg started in a direction that will miss the tree.

Fig 15

Temporary Cockshy in Traverse Work



When a big tree is lying on the ground, a station can either be made on the trunk, and the theodolite used with or without its tripod; or a temporary cockshy can be made as shown in Fig. 15. The cockshy, a stout pole, is driven firmly into the ground and plumbed over

the picket. The ray is taken to the plumbob string, thickened if necessary by paper rolled round it.

A similar procedure is useful in getting over humps in the ground, but the surveyor has always to consider whether the waste of time entailed by the use of temporary cockshies is worth the extra length of leg obtained, and the loss of accuracy when the leg is very short. In any case he must do the plumbing himself.

Object and Error of Traverse Azimuth.

164. (a) The objects of observing are to prevent the accumulation of error due to constantly measuring the included angles of the traverse legs, and also to take account automatically, as it were, of the convergency of the meridian.

(b) *Error.*—If each included angle is liable to be 20″ in error, then, if there are thirty-seven legs, the error of the last leg will be $20'' \times \sqrt{37-1}$, *i.e.*, 120″. The mean error will therefore be about 60″. If the legs are about 300 feet long, the traverse will be about 11,100 feet long, and the error of position will be about 3 feet laterally, or about 1 : 3500.

Thus, if an azimuth were observed at every 2 miles, the error would be satisfactorily small. In the dense forest country, however, it is usually only at villages in large clearings that an azimuth can be observed. Generally speaking, these villages are from 4 to 6 miles apart, so that if the rough rule is followed of observing azimuths at intervals of about 5 miles, there would be about eighty-two legs of an average length of about 320 feet. The error of the last leg would then be about 180″, and the mean error about 90″. This would give an error in position of about 11 feet laterally, or about 1 : 2400.

This is sufficiently accurate; hence the rule, *observe an azimuth about every 5 miles.*

It is not always possible to carry out this rule, but the system by which the included angles are measured is sufficiently accurate to allow occasionally of longer distances between azimuth stations, as several times proved in the Gold Coast survey. On one occasion it was found impossible to obtain an azimuth for over 200 legs. The closing error in this case proved to be under 30″, and, though errors must have balanced, the surrounds subsequently completed, and the close agreement of traverse and astronomical amplitudes showed that no serious error existed in the 14 miles of traverse.

In view of the example furnished by this by no means exceptional case, it would seem that 5 miles is too small a distance between azimuth stations. On the other hand, gross errors of several minutes may at any time be caused by such things as the unnoticed displacement of a picket, and great labour caused by a retraverse.

Rules for Observing Traverse Azimuths.

165. *Sun Azimuth.*—When there are approximately ten legs, or less, per mile, an azimuth may be observed to the sun: these conditions will usually only occur in beach traverses. The mean of three sets of observations must be taken. The probable error should not exceed 20″. Correction should not be made for semi-diameter but equal pairs of opposite limbs observed. The observations must be made before 9 A.M. or after 3 P.M. Test for

gross error by compass bearings. *See* para. 163 (b). The limbs should be observed thus :—

(b) *Star Azimuths.*—When there are more than ten legs per mile, azimuths must be observed to three pairs of east and west stars at altitudes of less than 50°. If two pairs are worked out and agree there is no necessity to work out the third pair. *See* para. 136 (c).

(c) *Probable Error.*—The probable error of the arithmetic mean of the four or six sets of observations should not exceed 5″, *i.e.*, the results should be covered by about 30″.

Example.—The probable error of the arithmetic mean of a number of observations

$$= 0{\cdot}674 \times \sqrt{\frac{\Sigma r^2}{n(n-1)}}$$

where n is the number of observations and Σr^2 is the sum of the residuals.

Suppose the azimuth resulting from two pairs of stars are worked out and are found to be 10° 12′ 50″, 20″, 30″ and 40″.

	″	r	r^2
	50	15	225
	20	15	225
	40	5	25
	30	5	25
Mean	35		$\Sigma r^2 = 500$

Probable error of the mean azimuth (10° 12′ 35″)

$$= 0{\cdot}674 \times \sqrt{\frac{500}{4 \times 3}} = 4{\cdot}34''$$

It should, however, be noted that it is rather dangerous to derive a probable error from only four observations.

(d) *Latitudes and Times.*—Instructions for observing are given in Chapter IV. It is not necessary to take observations for time when observing an azimuth, but the approximate time to within a quarter of an hour must be known. It is not necessary to observe the latitude of each azimuth station with the theodolite, that of every second or third station being sufficient, the latitudes (which are only wanted approximately for computation work) of the intermediate azimuth stations being computed from the traverse tables in Chambers', or measured off the auxiliary sheet.

(e) *Azimuth Marks.*—It is not necessary to observe the azimuth of the actual leg of a traverse. As beacons are generally left to preserve the azimuth for the use of future survey parties, it is generally more convenient to put one or both of them off the line of

traverse. These beacons should be erected before the azimuth is observed or the included traverse angle measured. If this is not possible, great care should be taken in centering them accurately.

(f) *Referring Object.*—As some difficulty may be experienced in getting a longer leg than 300 to 400 feet, the following kind of referring object (R.O.) for night work is recommended.

For the referring object use the same picket and pin, *see* para. 166 (b) that was used in the traverse. This should have been carefully fenced in to preclude any chance of its having shifted. Or, if a beacon has been put in, place the pin in the hole in the top. About 6 inches behind the pin place a lamp giving a good light, and raised on a rough table if necessary. Between the lamp and the pin stretch a piece of thin white notepaper on a small frame. It will then be found that the pin will show up clearly against the white background so obtained. The size of the pin can be varied according to its distance from the theodolite, and the thickness of the paper is also a matter in which the surveyor can suit himself.

(g) All observations and computations are to be entered and worked out in the astronomical angle books and computation forms provided for that purpose, and these must be carefully completed in all respects, and handed into Headquarters at the end of the season.

(h) The result of azimuth observations, and the distinguishing numbers of the beacon at which they were taken must be sent to Headquarters monthly.

General Remarks on Angular Measurement.

166. (a) There are two methods of measuring the traverse angles according to the class of traverse, viz., the Gold Coast method for primary traverses, and the repetition method for secondary traverses. These are respectively described in paras. 167 and 169.

(b) *Objects read to.*—As mentioned in para. 163, stout pickets firmly driven into the ground are used for stations. These pickets are too large for satisfactory intersection at close range. The traverser should observe to a small nail driven lightly in the top of the picket. When the leg is very short a needle or pin may be used; when longer than 400 feet, a small stick about the size of a lead pencil. The station boys should carry a supply of different-sized pins, nails, and sticks for use at various ranges, and the surveyor should arrange a code of signals for altering the size. The surveyor should invariably make a small indelible pencil or ink circle around the point where the nail is driven into the picket, as the back station boy may have to replace the nail by a stick if the length of the leg being measured is greater than the last one dealt with.

In the gloom of the forest it is often difficult to intersect the nail, and the surveyor will find it a great help if each of his station boys carries a square of paper on a board which he can hold behind the pin.

(c) By para. 52, Table XIII., the traverser requires the following party: two station boys to place nails in pickets, hold back-screens and sight-vanes, and guard the station during measurement of angles and also during chaining, and to carry the theodolite boxes; one theodolite boy, who carries the theodolite from station to station;

one plane-table boy and five chainmen working with the assistant as a chaining party.

(d) *The whole party must be cautioned not to touch the pickets until after they have been used as back stations.* On stopping work at night always, and also for the midday halt where there is traffic, the two stations in use must be securely fenced in to prevent people or goats disturbing them.

(e) A sheet of white paper, or the field book, held under the vernier will greatly assist the surveyor in reading the arcs in the gloom of the forest.

(f) When working in the open, it is strictly ordered that the observer should protect his head and back with the survey umbrella provided by Government for that purpose. The use of the umbrella to shade the theodolite is not essential, although the bubble levels have been known to burst in a hot sun.

167. (a) The Gold Coast method will be strictly adhered to in all primary theodolite traverses. The following is the method, the letters in brackets referring to the specimen page of angle book given in this paragraph.

Gold Coast Method.

When reading the description of the method employed observers are cautioned not to confuse swing right and swing left with the motion of *the slow-motion screw, which must always be revolved against the spring, i.e., clockwise.* Swing right and left apply respectively to the direction in which the instrument is revolved when the top plate is unclamped.

I. Clamp the top plate with vernier reading between 0° and 5°, *face right.* Intersect back station roughly and clamp lower plate. Intersect back station accurately with the top plate slow-motion screw.

II. Read the back angle on both verniers (B, B′).

III. Take the mean (M).

IV. Unclamp top plate, *swing right*, and roughly intersect the forward station, then clamp top plate and intersect accurately with top plate slow-motion screw.

V. Read the forward angle on both verniers (F, F′).

VI. Take the mean (M′).

VII. Subtract M from M′ and get the included angle (A).

VIII. Read the vertical angle to the forward station and bubble (V).

IX. Reverse the telescope, unclamp both the plates, set the vernier at about 35°, clamp top plate, intersect back station roughly and clamp bottom plate. Intersect the back station accurately, *face left.*

X. Read the back angle on both verniers (b, b′).

XI. Take the mean (m).

XII. Unclamp top plate and *swing left* on to forward station. Clamp top plate and intersect with slow-motion screw.

XIII. Read the forward angle on both verniers (f, f′).

XIV. Take the mean (m′).

XV. Subtract m from m′ and get the included angle (a).

XVI. A and a should agree by about 10″ with a good observer and good instrument. If they differ by more than 20″ a third round

SPECIMEN PAGE

ANGLE BOOK

Gold Coast Method

(For explanation see para. 167)

										(V)	0°	48′	10″ 20	E = 70 = 5			
(F.L. S.L.)				(F.R. S.R.)						(V)	179	11	30 34	E = 60 = 6			
(f)	200	10′	36″	164	20′	40″	(F)										
(f′)			38			44	(F′)					354°	45′	Mag.			
(m′)			37			42	(M′)										
(c)	164		10		21		29			342°		10		21″	(d)		
(b)	36	0	10	0	10	20	(B)										
(b′)			16			28	(B′)										
(m)			13			24	(M)										
(a)	164	10	24	164	10	18	(A)										

Note.

The letters in brackets are explanatory only. The bearing of the leg 28 to 29 is supposed to be 8° 0′ 10″.

of angles must be taken, as in I. to VIII., with the vernier set at about 100°.

XVII. The mean of A and a (or the mean of A, a, and any other round) is taken as the included angle (c) and is entered on the left of the station, as shown in the field book.

XVIII. The included angle is then applied to the bearing of the last leg and is entered on the right of the station (d). This is the "false bearing" of 29 to 30, as mentioned in para. 161, 4th process.

XIX. Check the false bearing for gross errors by the compass.

XX. Read the vertical angle on the forward station and the bubble (v).

(b) It will be noticed that the vertical angle to the front station only is read, and this after the horizontal angle has been dealt with. The observer intersects a sight-vane adjusted to the height of the theodolite. If the sight-vane is invisible (as in the case given in para. 163, d) the height of the point observed above the sight-vane must be known.

The sight-vane carried by the station boy can be roughly constructed of an old banderole with a sliding cross piece. The vertical angle measurements are not intended to carry a line of levels for the vertical framework of the survey, as the system would be too inaccurate considering the short legs obtainable.

Traverse Field Books.

168. (a) All angular measurements will be entered in the Theodolite Traverse Angle Book, as shown on the specimen page in the last paragraph. No other entries except the number of the station, the magnetic bearing, and entries *re* start and close of daily work will be made in this book. Separate pages will be kept for rounds of angles taken to distant objects.

(b) All chaining and details are kept in the Theodolite Traverse Chain Book.

(c) The remarks given in para. 70, (b), (c), (d), and (e), apply to theodolite traverse field books, both the angle book and the chain book.

(d) The instructions given in para. 117 (b) must also be adhered to, though the surveyor will have to make certain alterations in the forms as follows:—

In I., delete *Compass* and substitute *Theodolite*.

In II., under *Compass* put *Theodolite No*.....

In III., put the result of checking the compass magnetic variation at the last azimuth station.

(e) Generally speaking, the theodolite traverse chain book is kept as laid down in para. 70.

Repetition Method.

169. (a) The repetition method is simpler and more expeditious than the Gold Coast method, and will be used in all secondary theodolite traverses. The letters in brackets refer to the specimen page.

I. Clamp the top plate with vernier reading between 0° and 5°, *face right*. Intersect back station roughly and clamp lower plate. Intersect back station accurately with top plate slow-motion screw.

SPECIMEN PAGE

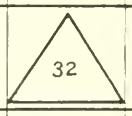
ANGLE BOOK

Repetition Method

(For explanation see para. 169)

(Vertical angles as in last example)

	(F. L.	S. R.)	(F. R.	S. R)	
(f)	340	38 55	170	24 30	(F)
(f')		39 05		40	(F')
(m')	340	39 00	170	24 35	(M')
(c)	170°	14′	17·5″		
			0	10 20	(B)
				30	(B')
(m)	170°	24′ 35″	0	10 25	(M)
(a)	170°	14′ 25″	170	14 10	(A)



35° Mag.

21° 05′ 07 5″ (d)

Note.

The letters in brackets are explanatory only. The bearing of the leg 31 to 32 is supposed to be 30° 50′ 50″.

II. Read back angle on both verniers (B, B′).

III. Take the mean (M).

IV. Unclamp top plate and *swing right* on to forward station. Clamp top plate and intersect with top plate slow-motion screw.

V. Read the forward angle on both verniers (F, F′).

VI. Take the mean (M′).

VII. Subtract M from M′ and get the included angle (A).

VIII. Read the vertical forward angle and book as in para. 167, VIII.

IX. Unclamp bottom plate only, reverse telescope, and get *face left*. Set on back station, clamp lower plate, and intersect with lower plate slow-motion screw.

X. *The top plate not having been unclamped*, the back reading should be the same as M′. Check it by reading the verniers, and enter it (m).

XI. Unclamp top plate and *swing left* and intersect forward station, as in IV.

XII. Read both verniers (f, f′).

XIII. Take the mean (m′).

XIV. Subtract m from m′ and get included angle (a).

XV. A and a should agree by about 15″ with a good observer. If they differ by more than 30″ take a third round by reversing the telescope and setting on the back station with the vernier reading, the same as in XII.

XVI. The mean of A, a, and any other round is taken as the included angle (c).

XVII. Obtain false bearing (d), by applying (c) to the false bearing of the last leg.

XVIII. Check the false bearing for gross errors by the compass.

XIX. Read the vertical angle to forward station, as in para. 168, XX.

(b) The remarks in para. 167 (b) and in para. 168 also apply to the repetition method.

170. The fourth, fifth, and sixth processes require but few remarks. The deduction of the false bearing, which is the true bearing ± accumulated errors, is mentioned in para. 167, XVIII., and is facilitated by drawing a rough diagram.

Limit of Angular Error.

Generally speaking, in primary theodolite traverses the closing error does not generally exceed from 1″ to 3″ per leg. A re-survey is necessary if the closing error causes an error greater than 1 : 2000 in the traverse. To ascertain this, halve the difference between the false bearing and observed azimuth of the last leg, and calculate the error that will be caused by this angle in the length of the traverse.

The limit of error for secondary theodolite traverses is 1 : 1000.

171. (a) In both classes of traverse, the double chaining system given in para. 108 is adopted with the following refinements :—

Chaining.

I. The temperature of the steel band is taken every time it is laid, and the temperature entered in the right-hand column. Correction for expansion is made when the measured length is entered in the co-ordinate sheets.

II. Generally, and especially in very hilly country, the slopes are observed with the theodolite, or with the Close-Brooker alidade, to get accurate correction. Except in very hilly country the Abney level is good enough for secondary traverses.

III. The discrepancy between the long and short band must not exceed 1 : 2000, *i.e.*, 1 lk. for every twenty short bands for primary traverses, 1 : 1000 for secondary traverses.

(b) All chaining records are entered in the Theodolite Traverse Chain Book, which is kept as in the specimen page in para. 118, except that magnetic bearings are only read "forward," and need not be reduced to the true north. In the bearing column the false bearing will be deducted from the mean magnetic bearing, thus giving a fair idea of the amount of magnetic attraction existing locally.

(c) In secondary theodolite traverses Method A, para. 113, can be made use of if it is found that it does not produce a discrepancy of more than 1 : 1000 between the bands.

(d) The traverser should always use his assistant for the check chaining, and do the long band chaining himself.

Topographical Detail.

172. (a) When a theodolite traverse forms part of the work of an ordinary field camp, topographical detail will be kept up to date on the auxiliary sheet. When a subsection has been completed, and co-ordinates calculated, the traverse is transferred to the field sheet, as in para. 102 (d).

(b) When the traverse is being done by a special party told off for the framework only, field sheets need not be kept, the auxiliary sheet being sufficient. The surveyor must take care to show all topographical detail on the line of traverse, and to leave numerous beacons and blazed and numbered trees, as laid down in para. 83, for the use of future topographical parties.

Co-ordinates.

173. (a) Co-ordinates will in all cases be taken out of Boileau's or Gurden's tables to the nearest minute, but any legs that are longer than 2000 feet will be calculated by log cos and log sin. They will be checked for gross errors by Chambers' Latitude and Departure Tables. Both the computation and checking are the duties of the camp officer and his assistant, and every subsection will be initialled by both.

(b) In certain cases the computation or the checking, or both, of co-ordinates by the Topographical Office may be sanctioned. In these cases the surveyor must enter in the co-ordinate sheets the station, true bearings, and distances, and, after checking them carefully with his assistant, send them to Headquarters.

Field books are not to be sent until the receipt of the co-ordinate sheets is acknowledged.

(c) Co-ordinates are totalled by subsections, *vide* para. 160 (f), that is, the co-ordinates of each subsection are referred to the *last station* of the previous subsection. A summary of the subsection co-ordinates, giving the co-ordinates of the last station of each subsection referred to the starting point or "origin" of the whole section, must be attached to the co-ordinate sheets.

(d) All co-ordinates will be signed by computer and checker, neatly bound with clips and red tape, and labelled.

174. The following is a summary of conditions and errors for the two classes of theodolite traverses:—

Summary of Conditions and Errors.

	Primary.	*Secondary.*
Traverse angles . .	± 20″	± 30″
Azimuths . . .	± 20″	± 20″
Chainage	1 : 2000	1 : 1000
Longitude (telegraphic) .	± 3·0″	± 3·0″
Latitude	± 0·5″	± 1·0″
Theodolite . . .	6″ or 5″ (Micro)	6″ or 5″

In view of the system adopted, and by limiting the errors as above, the resulting error of the two traverses will probably not exceed about 1 : 2500 and 1 : 1500 respectively, although errors of 1 : 2000 and 1 : 1000 only are aimed at.

River Theodolite Traverses.

175. (a) In the dense mangrove and forest belt in the southern part of the Central Province the only possible way of forming a framework for the standard map is by executing a subtense traverse of certain of the chief rivers.

(b) As these rivers are used for steamer traffic, an endeavour is made to combine the work of surveying with that of assisting the Southern Nigeria Marine in beaconing, buoying, and sounding the main channels.

(c) With the object, therefore, of combining the work of making the standard map with that of making a reliable chart, auxiliary sheets should not be drawn on a scale of less than 1 : 31,250, even though the survey may be along a river where rays of from 2 to 4 miles are obtainable, and a smaller scale might, under ordinary circumstances, be sufficient to show the topography of the country.

(d) River theodolite traverses are usually executed by field camps especially detailed for the purpose, the topography of the surrounding country being surveyed later.

General System of River Survey.

176. (a) The horizontal angles of the traverse are measured by the Gold Coast method, as in primary theodolite traverses.

(b) The length of the traverse legs are measured on the Tanner system, the angle subtended by a bar of known length being measured. (Paras. 177 and 178.)

(c) The operations in (a) and (b) are conducted independently, (b) preceding (a). The angular and subtense measurements are kept separate, being entered in the Traverse Angle Book and Traverse Chain Book respectively.

(d) On the conclusion of the traverse measurements the surveyor fixes by the subtense method the positions of certain intermediate points on both banks of the river, and on sandbanks and islands by the Tanner method, but less rigorously than in (a) and (b). The number of these intermediate points varies with the width of the

river and the length of the traverse leg obtainable, but there should be sufficient for the plane-tablers to work on.

(e) One or more plane-table parties follow the traverse, completing the topographical detail of the river. (Para. 183, IV., V., VI.)

(f) Two plane-table parties follow the topographical plane-table parties, fixing the soundings made by the Marine officer. (Para. 186.)

(g) All topographical detail is plotted directly on the auxiliary sheets by the plane-tablers, field note-books and village and river field books being used where necessary.

(h) The camp officer keeps his traverse and intermediate points plotted on his own auxiliary sheet, and enters up to date every night the work of his plane-table parties.

(i) Occasionally the country through which the river flows becomes open for a width of several miles and for several miles in length. On these occasions the camp officer should endeavour to obtain a suitable chained base, and replace the traverse by triangulation. Should he consider that the length of the open country does not warrant this change of system, he should in any case triangulate conspicuous distant points in the open belt, beaconing those likely to be of use to future topographical parties.

(j) When the traverse arrives at broad estuaries, as at Forcados, Bonny, etc., it should be replaced by triangulation.

Subtense Bar.

177. (a) The bar is circular and is made of hardwood in three sections. The centre section is long enough to allow two discs to be clamped to the ends and 10 feet apart. The ends of the centre section are brass shod to fit into brass sockets at the ends of the other two sections, thus extending the bar sufficiently to allow the discs being placed 20 feet apart.

(b) Around the middle of the centre section is a brass sheath around which fits a brass carrier with just sufficient play to allow the centre section to be revolved, a thumb-screw being provided to clamp the carrier to the sheath.

(c) A telescope with focussing screw is rightly attached to the brass carrier to enable the bar to be adjusted at right angles to the ray.

(d) A spirit level on the brass carrier ensures the bar being horizontal.

(e) Attached to the underside of the brass carrier is a brass pin which revolves and can be clamped in a brass plate on three foot-screws, which in turn are supported on a stout tripod with a head similar to that of a theodolite.

(f) The discs are circular and made of aluminium, 18 inches in diameter, with a square brass socket and clamping screw at the back. The discs have a white circle 2 inches in diameter painted in the centre. Around this is a black circle 6 inches in diameter. The remainder of the left-hand disc is painted red and the remainder of the right-hand disc white, viewed from the theodolite. In the centre of each disc is a cross marked in the aluminium.

(g) A steel band, $\frac{1}{8}$ inch wide, with a handle at each end and marked at 0, 10 and 20 feet, is carried in the subtense bar case for checking the distance apart of the crosses on the discs.

(h) The subtense bar is packed in two cases, the weight of each when full not exceeding 56 lbs. The tripod is provided with a stout leather cap and is carried unpacked.

(i) The centre section should occasionally be revolved 180° in the carrier to prevent any tendency to sag from constant use in one position.

(j) The 20′ bar is used at ranges exceeding 1½ miles, the 10′ bar for lesser ranges.

(k) In high winds the ends of the bar are supported by light iron uprights, stayed by tent ropes and pickets.

(l) Two uprights, four tent ropes, a small oil can, screw-driver and pliers are provided with each instrument.

(m) Three wooden discs, 9 inches in diameter and ¾ of an inch thick, are provided. These fit on the legs of the tripod about 3 inches from the ends for use on marshy soil.

178. (a) The subtense system used is practically that known as the "bar-subtense," introduced in the survey of India by Colonel Tanner, R.E., and largely used in the survey of the Himalayas. It was used in the survey of the Ofin, Ankobra and Volta rivers in the Gold Coast and Ashanti. On the Ofin the average length of ray was about 1000 feet and the traverse closed well with other primary theodolite traverses. On the Ankobra and Volta the rays increased to about 3000 and 7000 feet respectively.

Tanner Subtense System.

(b) *Correction.*—The camp officer should, by actual experiment on chained distances or at trigonometrical points, ascertain if there is any correction of the distance given in the subtense table.

(c) The error due to the system probably amounts to about 1 : 1000. The error due to the subtense bar being thirty-five minutes out of correct alignment is given by the *Indian Handbook* as about 1 : 10,000.

(d) The subtense angles are measured by three sets, each of ten repetitions, each set on a different zero up to ranges of three miles; over ranges of three miles, four sets; over four miles, five sets, etc.

(e) For subtense measurements only it is sufficient to centre the bar within 1½ inches.

(f) *Caution.*—If the subtense angle is so large that the tangent screws will not cover the ten repetitions, six sets of five repetitions must be taken. Part of the object of No. VII. in the next paragraph is to ascertain this. The surveyor knows the angle through which the tangent screws will revolve the top plate, and if this angle, divided by ten, is less than the subtense angle determined in VII., he should use six sets as stated above and not ten.

179. The following is the system of measuring the subtense angle, the letters in brackets referring to the specimen page at the end of the paragraph.

Measuring the Subtense Angle.

I. Set both tangent screws back to the commencement of their runs; face right. Give each a final slight clockwise twist.

II. Set the vernier between 0° and 5° clamp top plate.

III. Intersect left disc approximately and clamp bottom plate.

SPECIMEN PAGE

SUBTENSE ANGLE BOOK

	Vernier A.		Vernier B.		Mean.		
100	56′	10″	14″		56′	12″	
100	05′	35″	45″		05′	40″	
				10	50′	32″	
			3rd Set	=	05′	03·2″	(G)
36°	15′	55″	65″		76′	00″	
35°	25′	15″	21″		35′	18″	
				10	50′	42″	
			2nd Set	=	05′	04·2″	(F)
02°	00′	18″	24″		60′	21″	(C)
01	15′	24″	30″		15′	27″	(B)
01	10′	20″	28″		10′	24″	(A)
				10	49′	57″	(D)
			1st Set	=	04′	59·7″	(E)
			Mean	=	05′	02·3″	(H)
			Feet				(J)
			Correction	=			(K)
			Ray	=			(L)

Station 79 to Station 80

Note, The letters in brackets refer to the text in para. 179

IV. Intersect left disc accurately with either tangent screw, being careful to use here, as always, a clockwise twist.

V. Read both verniers and take the mean (A).

VI. Intersect right disc by top plate tangent screw only.

VII. Read verniers and take the mean (B). This is done to ascertain the approximate subtense angle ; the right disc is not read again until the tenth reading. Make sure that the tangent screw will cover the set, para. 178 (f).

VIII. Intersect left disc with lower plate tangent screw only, then intersect right disc with top plate tangent screw only.

IX. Repeat No. VIII. eight times, reading no verniers until the right disc is intersected for the tenth and last time, when the verniers are read and the mean taken (C).

X. Subtract reading of left-hand disc (A) from last reading of right-hand disc (C) and get the difference (D).

XI. Divide the difference by ten, the total number of repetitions, and get the mean subtense angle (E).

XII. This completes the first set.

XIII. Theodolite still face right, zero of about 35°, repeat I. to XII. except VII., and get a second value of the subtense angle (F).

XIV. Theodolite still face right, zero of about 100°, repeat I. to XII. except VII., and get a third value (G).

XV. Take the mean (H) of the three values.

XVI. Look up the distance (J), corresponding to (H) in the subtense table, and enter it.

XVII. Apply the correction (K), if any. *See* 178 (b).

XVIII. Enter final measurement in feet (L) under forward station.

180. (a) Subtense tables are calculated from the formula, $d=\frac{l}{2}\cot\frac{s}{2}$, where d is the distance in feet, l = distance in feet between discs, s = angle measured.

Computation of Distance.

(b) Should no tables be available, the formula $d=\frac{l}{s\times\sin 1''}$ gives an error of less than 1 : 600,000 and is practically accurate, as well as often convenient, as the aid of logs may be dispensed with.

$\frac{l}{\sin 1''}$ is a constant, and it is only necessary to divide it by s, reduced to seconds, to get the distance.

Example.—If a 20′ bar is being used, $\frac{l}{\sin 1''}=4125296$. If the subtense angle s is 40′, the distance $=\frac{4125296}{40\times 60}=1718$ feet

181. (a) In fixing intermediate points less rigorous methods may be employed than in the traverse measurements. It is sufficient if the false bearings to these points are measured on the repetition method (para. 169), but the surveyor may use either method *so long as he completes the measurement of the traverse angle before he starts fixing the intermediate points.*

Intermediate Points.

(b) The subtense measurements of intermediate points may consist of the following sets:—

Distance in Feet.	*Number of Sets.*		*Number of Repetitions in each Set.*	
	10-ft. Bar.	*20-ft. Bar.*	*10-ft. Bar.*	*20-ft. Bar.*
0 to 2000 . . .	2	2	5	3
2000 to 5000 . .	3	3	8 to 10	5
5000 to 10,000 . .	—	3	—	8
10,000 to 15,000 .	—	3	—	10
Over 15,000 . .	—	4	—	10

(c) In many cases it will be possible to intersect the intermediate point from the two traverse stations, in which case no subtense measurement need be made.

(d) Angular and subtense measurements are entered in the same field book, but a separate page must be kept for each, and also for each intermediate station, which must be given a distinguishing letter and described.

182. *Field Camp for River Traverse.*

Observing Party—

1 Camp Officer.
1 First-class Headman.
1 Theodolite Boy.
1 Plane-table Boy.
2 Boatmen.
1 Launch.
1 Boat to carry eight persons and instruments.

Advance Party—

1 Assistant.
4 Boatmen.
1 Canoe to carry six persons and subtense bar.

Three Bar Parties—

3 Second-class Headmen.
6 Boatmen.
3 Canoes, each to carry three persons and subtense bar.

Two Plane-table Parties—

2 Assistants.
2 Plane-table Boys.
4 Boatmen.
4 Banderole Boys.
2 Canoes, each to carry six persons and instruments.

Summary.—1 Camp Officer, 3 Assistants, 4 Headmen, 8 Survey Boys, 16 Boatmen, 1 Launch, 1 Boat, 6 Canoes. *Total*, 32 persons.

Note.—The boatmen must be engaged for general work, and can best be obtained through the Southern Nigeria Marine.

Cost, excluding Camp Officer, Assistants, and Launch, £1, 7s. 9d. to £1, 11s. 9d. per diem.

183. I. *Observing Party*—

Distribution of Work.

(a) Measures subtense angle, and on completion signals to advance party to move on.

(b) Measures horizontal angle to back and forward stations.

(c) Measures both angles to intermediate points.

(d) Plots auxiliary sheet.

(e) Takes soundings at about every 100 feet across the river at each traverse station on a known bearing. (Omitted if sounding party exists, para. 186.)

II. *Advance Party.*—Clears forward station, erects and removes subtense bar.

III. *Bar Parties.*—Erect bars at intermediate points indicated by camp officer. On receiving signal from camp officer that the observations to his bar are completed, the headman replaces his bar by a banderole. (*See* example in para. 187.)

IV. *Plane-table Parties.*—One plane-table party surveys each bank with plane table. If the intermediate points are well placed, the plane-tabler should always be able to obtain three points from them and the traverse stations by which to interpolate his position. If only two are visible, the trough compass should be called into use as the local magnetic variation can always be obtained from the traverse. Each plane-table party has two banderole men, so the plane-tabler should be able to utilise one of his previous plane-table fixings if only two points are visible.

V. Unless especially ordered, the plane-table parties will not survey any topographical detail lying more than 100 yards from the river banks, but exceptions to this rule should be made in those cases where villages are lying within a reasonable distance, say ¼ mile, from the river, and also where a town on the river bank extends for some distance inland. Large villages and towns should be located by tertiary compass or tertiary plane-table traverses in dense forest country, rope or pace traverses being sufficiently accurate for less important detail. Should roads that are likely to form part of the future compass framework of the forest country lead into any of these towns, the camp officer should be careful to see that points are sufficiently accurately fixed in them for the said framework to close on.

The plane-table parties must be careful to plot the mouths of all creeks and tributaries, and to make a complete survey around all islands and sandbanks. The widths of such creeks and tributaries, and of the side channels around the islands, should be noted on the auxiliary sheet.

The names of all streams, creeks, and islands should be obtained.

The nature and height of the river banks above high water level at the time of survey should be noted on the auxiliary sheet.

VI. The plane-table parties will obtain the position of the intermediate points and the traverse stations from the camp officer as

he determines them. They will usually be working close behind him.

184. The launch is entirely at the disposal of the camp officer, who, however, must be careful not to interfere with the navigation, or to infringe the Regulations of the Southern Nigeria Marine.

Use of Launch.

It will be available for the living quarters of the camp officer, and will carry all stores and food supplies.

If room is available the assistants may also sleep on the launch if the camp officer thinks fit.

During the day the launch will be fully employed in towing and in assisting the field camp wherever the camp officer considers advisable.

185. (a) The general rules for the erection of survey beacons at villages, etc., will be observed, an eye being kept on the demands of future compass framework parties, as mentioned in para. 183, V.

Special Beacons.

(b) Special beacons to assist in the navigation of the river will be erected at points indicated by the officer, Southern Nigeria Marine, working with the field camp. If no such officer is present the special beacons will be erected every 5 miles or thereabouts, and their positions plotted on the auxiliary plan.

The pattern of the special beacons will be notified in survey circulars. As a rule they will consist of large sheets of galvanised iron painted white, cut in various shapes, and nailed to tree trunks about 30 feet above the ground. Trees to be at least 20 yards from the bank.

186 (a) If the Director of Marine attaches an officer to the field camp for the purpose of conducting special sounding operations, the field camp must be increased by two assistants and two plane-table boys, who will be entirely employed in plotting the positions of the soundings. Canoes and boatmen for these will be provided by the Southern Nigeria Marine.

Special Soundings.

(b) The sounding operations should under ordinary circumstances keep pace with the traverse, but should the camp officer find that his progress is retarded, he will represent the matter to the Marine officer with a view to obtaining a second launch to enable the sounding party to be detached from the field camp.

187. An example of the way in which a river survey may be worked is shown in Fig. 16. (A) First assistant and advance party taking main bar in canoe (a) to station 15, which the party has to select and clear.

Example of Work.

(B) Camp officer observing horizontal angle between 13-12 and 13-14. (d) is his boat, (e) is the launch.

(C), (C1), (C2) Second-class headmen taking intermediate bars to point selected by camp officer. (b), (b), (b) are their canoes.

Camp officer takes bearing and distance of these points, which are

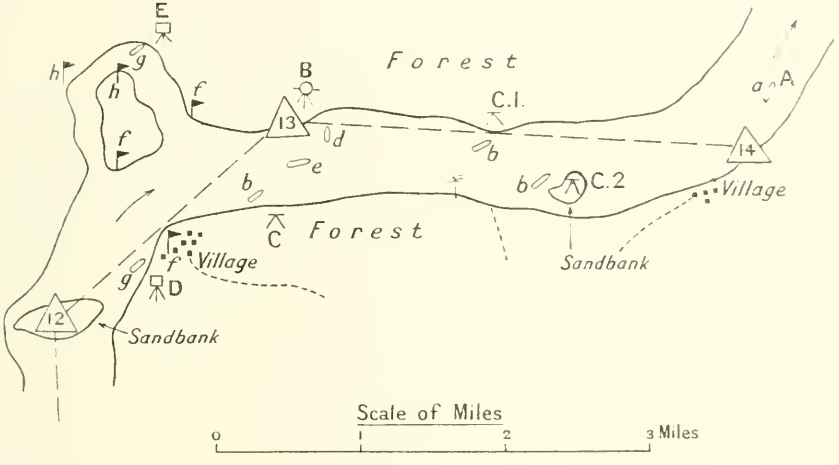
then marked with banderoles (with white flags, or basket-tops painted white), for the use of the plane-table parties.

One of these intermediate points (C) should be placed so as to give the width of the river at the station and also to give a line for the cross-soundings.

If necessary, (C) can be instructed to go on after he has been observed and place himself at a fourth intermediate point, leaving his banderole at (C).

FIG. 16

Sketch showing disposition of RIVER FIELD CAMP just after the subtense bar at Station 14 has been observed.—For description see para. 187.



The most valuable places for intermediate points are sandbanks (C2), as these are usually visible from nearly all points on both banks.

The camp officer plots his auxiliary sheet before he leaves the station.

(D) Right-bank plane-table party surveying right bank.

(E) Left-bank plane-table party surveying left bank.

(f), (f) (f) are banderoles fixed by camp officer from station 12.

(g), (g) are canoes of plane-table parties.

(h), (h) are red flag banderoles interpolated by Party E, as in 183, IV.

188. (a) In certain cases a theodolite traverse requires a certain amount of adjustment. For example, in para. 160 (c), it is mentioned that the mean of the astronomical and traverse latitudes and longitudes of "ruling points" are usually accepted.

Adjusting Theodolite Traverses.

Now suppose that a theodolite traverse runs from a fixed geographical point A to a point E, of which the latitude and longitude have been determined astronomically as 6° 20′ 10″ north

and 4° 10′ 30″ east, and that by the traverse the surveyor makes out that E is 6° 20′ 14″ north and 4° 10′ 24″ east.

Then the mean position of E is 6° 20′ 12″ north and 4° 10′ 27″ east.

This means that the traverse, when plotted in feet, will not fit on to E by about 2 seconds of arc in northing and 3 seconds of arc in easting.

These distances are scarcely plottable on the standard field-sheet scale, so that no adjustment of the traverse is necessary.

(b) But suppose as an extreme case that the traverse does not fit on to the mean position of E by 10 seconds of arc in northing. And further, suppose that the traverse is divided into four fairly equal subsections by azimuth stations at B, C, and D. Then the camp officer should work out the geographical co-ordinates of B, C, and D, from the traverse co-ordinates, correct them respectively by $2\frac{1}{2}''$, $5''$, and $7\frac{1}{2}''$, and plot them. Then the traverse subsections can be plotted in feet between these points.

Similarly, if there is a serious discrepancy in longitude.

Traverse and Astronomical Amplitude.

189. In comparing traverse and astronomical amplitudes, Survey Form No. 32 will be used. An example is given opposite, and explains itself. Tables III. and IV. are used for what is styled "log 1″," this being really the log of the value of 1″ in feet at the mean latitude as given in the tables.

AMPLITUDE COMPUTATION.

DATUM STATION A IS LAGOS OBSERVATORY

LATITUDE = 6° 26′ 41·2″ (AST)

LONGITUDE = 3° 23′ 49·8″ (TEL FROM CAPETOWN)

	°	′	″
LAT: OF A	= 6	26	41 2
APPROX: LAT: OF B (OBSERVED)	= 7	23	17·8
2	13	49	59·0
MEAN LAT:	= 6	54	59 5

	LATITUDE	LONGITUDE
T.D = 341693 feet		= 174172 feet
LOG: T.D.	= 5·5336361	= 5·2409784
LOG: 1″	= 2·0033756	= 2·0031175
LOG: T.A.	= 3·5302605	= 3·2378609
T.A.	= 0° 56′ 30·5″	= 0 28′ 49·3″
LAT: A.	= 6° 26′ 41·2″	LONG: 3° 23′ 49·8″
T. LAT: B	= 7° 23′ 11·7″	T. LONG: = 3 52′ 39·1″

Survey Form No. 32

REQUIRED STATION B IS Obsn. Post Station Yard, IBADAN

7° 23′ 17·8″ (AST)

3° 52′ 40·2″ (TEL FROM LAGOS)

FROM	TO	+N −S	+E −W	+N −S	+E −W
Obs	833	+340745·6	+173150·9		
833	833 A	+734·7	+ 908·5		
833 A.	O.P.	+212·9	+ 112·7	+341693·2	+174172·1

	°	′	″
OBS: LAT: B FROM	= 7	23	17·8
TRAV: LAT: B FROM LAGOS	= 7	23	11·7
,, ,, ,, ,,	=		
2			29·5
MEAN LAT: B	= 7	23	14·7
OBS: LONG: B	= 3	52	40·2
TRAV: LONG: B FROM	= 3	52	39·1
,, ,, ,, ,,	−		
2			79·3
MEAN LONG: B	= 3	52	39·1

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189

Connecting Theodolite Traverse with Triangulation.

190. (a) The junction between the theodolite traverse framework of the forest belt and the triangulation of the open country is effected by connecting each traverse with the nearest available trigonometrical point. Any discrepancy will be met by adjusting the traverse to the trigonometrical point, a sufficiently satisfactory arrangement when the probable errors of the two systems are considered, viz.:—

Triangulation, main	1 : 15,000
Do. minor	1 : 10,000
Intersected points	1 : 5,000
Primary theodolite traverses . .	1 : 2,000
Secondary theodolite traverses . .	1 : 1,000

Cases of serious discrepancy will naturally be subject to special investigation.

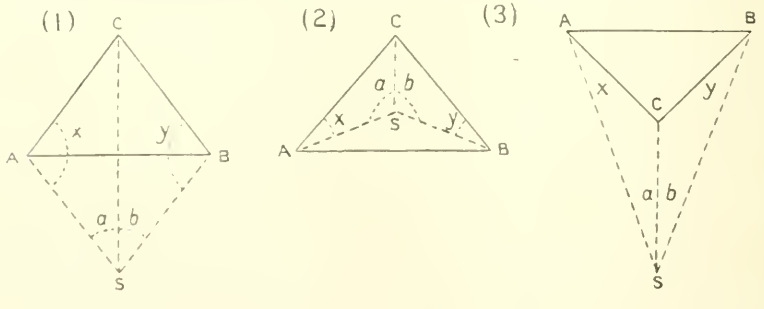
(b) An intersected point is the lowest class of trigonometrical point to which a theodolite traverse may be tied, and the last station of the traverse must always be marked by a survey beacon.

(c) The officer in charge of Trigonometrical Section ascertains from Headquarters the routes along which it is proposed to run theodolite traverses, and arranges for a trigonometrical point on, or as conveniently placed as possible in regard to, each route. The traverser should, therefore, usually be able to tie his traverse to the triangulation in what is the best and most expeditious way, viz., by direct chainage, and ending his traverse at the trigonometrical point.

Should this procedure, however, not be advisable owing to the loss of time involved, a fact which he should decide by consideration of the times required respectively to carry out direct chainage or any of the three methods about to be described, he has the choice of three systems according to the number of trigonometrical points visible.

Whichever system of the three he adopts, he must be careful to get his last traverse station in a position ensuring the necessary amount of accuracy.

(d) *By Interpolation of the last Traverse Station from Three or More Trigonometrical Points.*—The surveyor's position must not be



on or near the circumference of a circle passing through the trigonometrical points.

A round of angles on each face is taken to the three trigonometrical points. Then in each of the cases that may occur the position of the traverse station can be fixed by the above method, which is given in *Close*, p. 32.

Let S be the observer's position, A and B observed angles, then

$$x+y=360-(a+B+C) \text{ in (1) and (2)};$$
$$x+y=C-(a+B \text{ in (3)}.$$

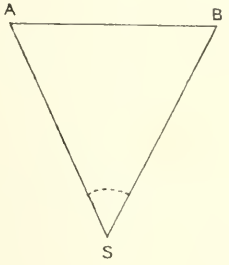
$$\text{Let} \qquad \tan\phi=\frac{-\sin a}{\sin B}\times\frac{a}{b}$$

$$\text{Then} \qquad \tan\frac{x-y}{2}=\tan(\phi-45^\circ)\tan\frac{x+y}{2}$$

This method is much strengthened if an azimuth is observed. The azimuth is also useful for correcting the false bearings of the traverse.

(e) *By Triangulation when only Two Trigonometrical Points are Visible.*—All three angles of the triangle formed by the two trigonometrical points and the traverse station must be observed, an azimuth being obtainable from the two trigonometrical points and applied to the traverse. This is the most satisfactory way.

If it is impossible to visit the trigonometrical points, the following method is given in *Close*, p. 33.



Let A and B be two known points. At S observe the angle ASB and the azimuth of SA or SB (by the sun will do).

Get some approximate value for the position of S from the plane table, or by traverse.

Then compute reverse azimuths of AS and BS, as below—

$$dA=dL\sin\lambda,$$
$$dA=\text{increment of azimuth in seconds},$$
$$dL=\text{difference of longitude in seconds of arc},$$
$$\lambda=\text{mean latitude}.$$

The way to apply the quantity dA can easily be seen by considering in which direction the meridians converge. Then knowing the azimuths of AS, BS, and that of AB (which is a known line), the differences give the angles A and B, and in the triangle ASB we know the three angles and one side (AB).

(f) *By Base Measurement and Triangulation when only One Trigonometrical Point is Visible.*—A base is measured in a convenient direction from the traverse station, and all three angles of the triangle are observed. No angle to be less than 10°. When at the trigonometrical point, an azimuth can be obtained and applied to the traverse by including any other visible trigonometrical point in the round of angles.

CHAPTER VI.

PLANE-TABLING.

200. (a) PLANE tables are used in the Southern Nigeria Survey for two entirely different purposes, *i.e.*, as portable tables and as surveying instruments.

Use as a Portable Table.

(b) A plane-table survey is defined in para 6 (p). Speaking generally, plane-table surveys are impossible in about three-fourths of the colony owing to scrub and forest. Here the plane table comes into use as a portable table. The compass traverser employed on filling in the block allotted to him sets up his plane table at his traverse stations, and plots on it his traverse and the topographical detail.

Having the actual features of the country under his eye, he is thus able to produce a far more satisfactory map than could be made from his field book, *and it is a stringent rule of the survey that this procedure should be carried out on all occasions.*

The system is of special value in drawing form-lines, the direction of these for a short distance after leaving the track, even in the densest forest, being approximately obtainable. For this reason the plane-table sketch must be plotted at every traverse station in hilly country.

(c) *The only exception* allowed is when the traverse is running through flat or gently undulating country covered by dense forest, scrub, or high grass. In these cases, no view being obtainable, the plane table need only be used at every fifth to tenth station, but must always be plotted up to date at every point where detail exists. In gently undulating country, however, the traverser must keep an eye on his aneroid entries, as appreciable differences in height are apt to pass unobserved.

(d) When using the plane table as a portable table auxiliary sheets are invariably used, the scale of the survey being usually 1 : 12,500, though any authorised scale may be used.

(e) In filling in his block the use of the plane table as a portable table is of supreme value in enabling the compass traverser to find out where he is. Instances occur when a graticule is the bounding line of his block, and by keeping his plot up to date the traverser can see when he has completed his overlap. Again, the track being surveyed may pass within a quarter of a mile or other short distance of some previously surveyed track, stream, or village without the surveyor being aware of the fact if he only uses his field book. With his constantly growing work under his eyes on the plane table he always knows where he is, and a rope partal run through the forest to the point mentioned will give not only a rough

check but also valuable assistance in determining the course of the form-lines.

(f) *Block Framework.*—In reference to the remarks in (d) and (e) the surveyor should have the framework of the block allotted to him plotted on his auxiliary sheet. In the majority of cases, however, this block will be too large owing to the scale of survey to go on one sheet, and in these cases he must either :—

I. Plot the framework on two or more sheets, which must be marked so as to join properly.

II. Carry with him a tracing of the block taken from the field sheet. On this he can reduce from time to time his auxiliary sheet to ascertain his position.

The first method is better as well as more expeditious and convenient, especially in the case of partly trained assistants, but the second may be used. Camp officers are responsible that their assistants are provided with this block framework before detaching them from the camp, and must bear in mind the fact that the value of the work produced is far in excess of the loss of the comparatively short period occupied in providing the framework plot.

In certain cases an unsurveyed stream or path may possibly form a bounding line to an assistant's block (*e.g.*, when, for convenience, only a part of a block enclosed by a surveyed framework is allotted to an assistant). In these cases the assistant should be given special instructions, and the result adjusted when the whole block has been completed.

Use as a Surveying Instrument.

201. (a) In open, and moderately open, country the value of a plane table as a surveying instrument is very great, both as regards convenience and rapidity, and its accuracy is unquestionable, especially if fitted with the Close-Brooker telescopic alidade. With this alidade, if due care is observed in levelling, in the selection of fixed points and in manipulation very accurate interpolations can be obtained. Conversely, a sufficiently accurate minor triangulation can be carried out with the plane table.

(b) All topographical detail is plotted direct on the plane table, and no field books except field note-books and river and village field books are necessary, and chaining is exceptional.

(c) When patches of forest, scrub, and tall grass are encountered, and trigonometrical points are lost sight of, the plane table need not, although it can usually with advantage, be superseded by the compass, any survey through them being executed by means of a secondary plane-table traverse, as described in para. 213 (a).

(d) With the telescopic alidade the determination of heights and form-lines is made accurate and simple.

(e) Correctly speaking, a plane-table survey does not include any system of survey which depends on the plane table being oriented by means of a compass, as the accuracy of the resulting map then depends on the amount of local magnetic attraction. The tertiary plane-table traverse described in para. 213 (d) is an example of one of these systems. As, however, the plane table is practically used as a surveying instrument under any of these systems, it is customary to include them under the heading of plane-table surveys, but *when*

a country is described as having been surveyed by plane table it must be understood that the compass has played little or no part in the operation.

Close-Brooker Alidade.

202. (a) This alidade consists, first, of a brass base plate, 18 by $2\frac{1}{2}$ inches, and about $\frac{1}{4}$ inch thick. To the right edge is attached the brass ruler, $\frac{5}{16}$rds of an inch wide, with a bevelled edge. This ruler can be pushed out parallel to, and an inch from, the base plate on the "lazy-tongs" principle. Thus it is not necessary to place the edge of the ruler against the fixed point on the paper when intersecting the actual point with the alidade. On the intersection being completed the ruler can be pushed out to the point on the paper, care being taken not to shift the base plate.

(b) Two spirit levels are at right angles to each other on the base plate for levelling the plane table.

(c) A 10-inch telescope is carried on the back end of the base plate on a column $5\frac{1}{2}$ inches high, which is hinged to the base plate so that it can be laid forward when packing. The telescope is fitted with focussing screw, adjustable direct and diagonal eye pieces, and cross wires, and is powerful enough to pick up a cockshy 15 miles away.

(d) On its left is a bubble level marked with divisions, and a vertical arc with vernier reading to minutes.

(e) The alidade was designed originally by Lieutenant-Colonel C. F. Close, C.M.G., R.E., improved by Major E. P. Brooker, R.E., and a diagonal eye piece with focussing screw added by the Southern Nigeria Survey. It is manufactured by Cary, Porter, Ltd., Pall Mall.

(f) Only the right edge of the ruler is used.

Southern Nigeria Plane Tables.

203. The plane tables used by the Southern Nigeria Survey are of three descriptions.

(a) *Mark I.* is a light military plane table made by J. H. Steward, 18 by 18 inches, with trough compass and wooden alidade. It is chiefly used as a portable table in forest country, and for the less important work in open country.

(b) *Mark II.* is a strong table made by Cary, Porter, Limited, with a 20 × 24 inch square board. It is provided with the Close-Brooker alidade, a trough compass, and a spare metal alidade.

(c) *Mark III.*, the *Southern Nigeria Plane Table*, is the latest and best pattern. The board is 24 inches square, and is mounted on a special tripod head provided with three foot-screws for levelling and a horizontal tangent screw for intersections. It is provided with the Close-Brooker alidade, trough compass, and spare metal alidade.

(d) It is with the Mark II. and III. plane tables and the Close-Brooker alidade that the chief work of surveying the more open parts of the country is executed.

(e) All plane tables are provided with covers, and the Mark III. tripod head has a special leather cover.

(f) The Mark II. plane table has three spare boards.

A zinc top, to which the field sheet can be pasted, and which is

clamped to the plane-table board, is provided for each Mark III. plane table.

(g) Mark IV. plane table is similar to Mark I., but has a board 20 inches square.

204.—Generally described, a plane-table survey consists of seven processes.

Processes in Plane-table Survey.

I. *The Preparation of the Plane-table Sheet.*—The field sheet itself is usually used by the camp officer and an auxiliary sheet by his assistant, though, if the latter is fully trained, the field sheet may be entrusted to him. The preparation of a field sheet with graticules and fixed points is fully described in paras. 58 to 62, and too much importance cannot be placed on the necessity of camp officers entering in their field note-books (para. 63) full descriptions of the fixed points on which they will have to base their work.

II. *Checking the Plotting of the Fixed Points on the Ground.*—This is done by "setting" the plane table as in para. 205.

III.—*Plane-table Triangulation.*—This is not always a part of the usual programme of a plane-table survey. The occasions on which it is undertaken and the process are described in para. 206.

IV. *Fixing Points by Intersection.*—This is described in para. 214 (l), (m) and (n).

V. *Fixing the Position of the Plane Table from Two or More Visible Fixed Points.*—*See* Plane-table Fixings (paras. 207 to 209).

VI. *Filling in Topographical Detail.*—This is described in para. 214.

VII. *Drawing the Form-lines.*—This is described in paras. 212 and 214 (m) and (o).

205. The following instructions, slightly altered, are given in the *Indian Handbook*, and will be the first thing to be done by the surveyor on reaching the scene of survey.

Setting a Plane Table and Testing Plotting.

(a) When commencing work the surveyor sets up his plane table on a prominent hill station, or well-fixed trigonometrical point situated in as commanding a position as possible, placing it level, and nearly over the station mark. He then orients his board, by placing his alidade so that its edge passes through the point at which he is standing and the most distant visible point plotted on his board, and turning the table bodily round in azimuth until the true distant point is intersected by the alidade.

(b) This is commonly called "setting" the plane table. With the Mark III. plane table the board must be clamped when the distant object is approximately intersected, and the final accurate intersection made with a *clockwise twist* of the tangent screw.

(c) He next tests the accuracy of every trigonometrical point on his board by laying his sight-rule in their direction in succession. If any are found to be wrong he must at once refer to his field note-book and check the plotting, correcting if necessary. The plotting given by the field note-book is to be accepted. If this is unsatisfactory, reference must be made to the camp officer, and by him if necessary to group officer.

(d) He now places the trough compass on some convenient part of the table outside the graticule, shifts it until the needle reads 0°, and marks on his board with a firm pencil line the edge of the box, thus obtaining the magnetic north. This magnetic north line must always be used subsequently for all ground in the vicinity of the station at which it was drawn. It is not used in the actual survey-work, only for convenience.

Plane-table Triangulation.

206. (a) Care is taken, as a rule, to fix as many minor trigonometrical stations and intersected points as possible during the execution of the main triangulation. In a country which is devoid of prominent artificial objects, such as church steeples, factory chimneys, etc., it is not always possible, without unduly delaying the progress of the main triangulation, to leave sufficient of the points in question for the use of the plane-tablers. In these cases it is the duty of the field camp to provide these points for itself by a plane-table triangulation.

(b) The points obtained by a plane-table triangulation are *plane-table trigonometrical stations* and *plane-table intersected points*, and must not be confused with *plane-table stations*, which are merely stations where a plane table is set up, or with *intersected points*. (An *intersected point* is one that has been fixed by the trigonometrical survey by theodolite from three stations.)

(c) A plane-table triangulation is carried out as follows:—

"Set" the plane table as described in para. 205 at three fixed points in succession on the triangulation of the colony. These fixed points are main or minor trigonometrical stations, or intersected points.

Draw rays from the three points to all points visible where it is desired to form plane-table trigonometrical stations.

Rays which meet at a less angle than 60° should be avoided, but with the Close-Brooker alidade rays meeting at angles greater than 45° will generally give good results.

The rays should all meet in one point. Should they form a triangle, the result is not satisfactory, and should not be used to make a plane-table trigonometrical station.

The result is a plane-table trigonometrical station, which would receive greater value if fixed from a fourth trigonometrical point.

(d) Before leaving the fixed points convenient prominent natural and artificial objects should be intersected by at least two rays, but the value of these is doubtful unless the plane-table *intersected points* thus obtained are very clearly marked on the ground or are fixed by three rays.

(e) *Temporary Cockshies.*—Scarcity of prominent objects necessitates in the majority of cases the erection of temporary *cockshies* before the plane-table triangulation is started. This entails a certain loss of time which is more than made up for by the greater rapidity and accuracy resulting in the topographical survey. The possession of a natural or trained "eye for country" by the camp officer tends very largely to the rapid selection of sites for such cockshies, and to the general efficiency of the plane-table triangulation. The cockshies need only be of the pole and brush pattern, either supported by a pile of stones, wedged between rocks, or stayed. The camp officer should

always leave a survey beacon buried at the foot of any cockshy marking a plane-table trigonometrical station (*see* para. 211).

(f) *Number of Points to be Fixed.*—In the Chapter on Triangulation it is laid down that a trigonometrical point should be left by the Trigonometrical Section in every 6 square inches of paper, *i.e.*, about 4 inches apart. It is impossible to lay down a hard and fast rule for the number of points per 6 square inches which should be fixed by the plane-table triangulation. As, however, the plane table is less accurate than the theodolite, a good rough rule to follow is to have about one plane-table trigonometrical station to every 4 square inches of paper, *i.e.*, about 2 inches apart or 2 miles on the ground on the 1:62,500 scale. This is sufficient in view of the fact that there will also be many plane-table intersected points to help the topographer.

In the "debatable zone," between the forest belt and the really open country, the number of plane-table trigonometrical points requires increasing according to the discretion of the camp officer.

(g) The plane-table triangulation can be extended if necessary by using the plane-table trigonometrical stations as "fixed points," but the value of the triangulation decreases appreciably the fewer the trigonometrical stations and intersected points there are among the "fixed points."

(h) The plane-table triangulation should be finally closed on the main or minor triangulation, or on the theodolite framework.

(i) Plane-table triangulation usually precedes the work of placing the topographical detail of the country on the field sheet, so that the accuracy of the plane-table trigonometrical stations may be verified by the "close" before being accepted as fixed points by the topographers. In some cases, however, the two surveys proceed concurrently, in which case the plane-table trigonometrical points are accepted as soon as fixed.

Plane-table Fixings.

207. (a) We will now suppose that the plane-tabler has completed checking his plotting of the fixed points at the trigonometrical station, as described in para. 205, and is ready to commence filling in the topographical details of the country.

This can be done in several different ways, all of which form part of the topographer's daily work.

By using the trigonometrical points (*i.e.*, stations and intersected points), he can intersect the various features of the country, and so put them on his paper. But these points are, as a rule, too far apart for convenience; he must make other fixed points for himself so that he can use them in combination with the trigonometrical points to form a series of short bases.

These points which he makes for himself are "plane-table fixings," which, defined, are those points which the plane-tabler visits on the ground, plots on his paper, and around and from which he fills in the topographical detail. A definition of a plane-table fixing is given in para. 6 (q).

Plane-table fixings are usually at or near some point where there is some natural or artificial feature, such as the junction of roads or streams, hill-tops, changes of direction in roads or streams, buildings, etc.

They may be prominent objects which are easily identified, but

more often than not in Nigeria their positions will have to be marked by banderoles.

Using two of these plane-table fixings as a base, the plane-tabler can intersect and put in detail of the country on each side, including the form-lines.

A plane-table fixing can be made either by "setting by the back ray" or by "interpolation," as described in paras. 208 and 209.

(b) *Number of Plane-table Fixings per Square Mile.*—In open country about four to five fixings per square mile are sufficient to enable a trained plane-tabler to show all the detail necessary on the field scale of 1:62,500. This gives the rough rule of from twenty-five to thirty per 6 square inches of paper.

In semi-open country, or in country very much broken up by irregular hills, the number must be increased to about forty-eight to seventy fixings per 6 square inches.

Unpractised plane-tablers require more points than experienced men.

In those rare cases where the field sheet is the same scale as the standard map the number of fixings *per 6 square inches* can be halved.

(c) Plane-table fixings are marked on the field sheet by small red crosses.

(d) Plane-table fixings should be made from fixed points. There is no absolute rule against using previous plane-table fixings, but it lessens the value of the work and every effort should be made to use nothing but trigonometrical points.

208. The *Indian Handbook* gives the following instructions, which are slightly altered here, for obtaining a plane-table fixing by "setting on the back ray":—

Setting by the Back Ray.

(a) From a fixed point the plane-tabler draws rays to any forward points which he considers suitable to visit for the purpose of sketching. These rays should be produced, and their extremities marked on both edges of the table. On arrival at the forward point he sets up his plane table over it, and "sets" his board by laying the alidade on the ray from the fixed point and revolving the board until the vertical wire intersects the fixed point.

(b) This is termed "setting by the back ray," and there is no better method of orienting, *i.e.*, placing the table in true azimuth. It is quite independent of abnormal compass variations, but it is essential that the same edge of the alidade be always used.

(c) The surveyor now draws rays from at least two other trigonometrical points to intersect the "setting ray," and so obtains his position on the paper. The point thus obtained is called a *plane-table fixing.*

The trigonometrical points selected should be, if possible, on both sides of the setting ray, and so situated that the rays from them are as nearly as possible at right angles to it.

209. The second method of obtaining a plane-table fixing is by interpolation, and there are two ways of doing this.

Setting by Interpolation.

(a) *Interpolation from Two Fixed Points.*—This is done by orienting the plane table with the trough compass. It is a bad system, and should only be resorted to under

very exceptional circumstances, and when only two fixed points are visible, as it entirely depends on the vagaries of the compass.

Set up the plane table at the desired point. Orient it by means of the trough compass. Lay the alidade against the plotted fixed point, intersect the real fixed point, and draw a ray.

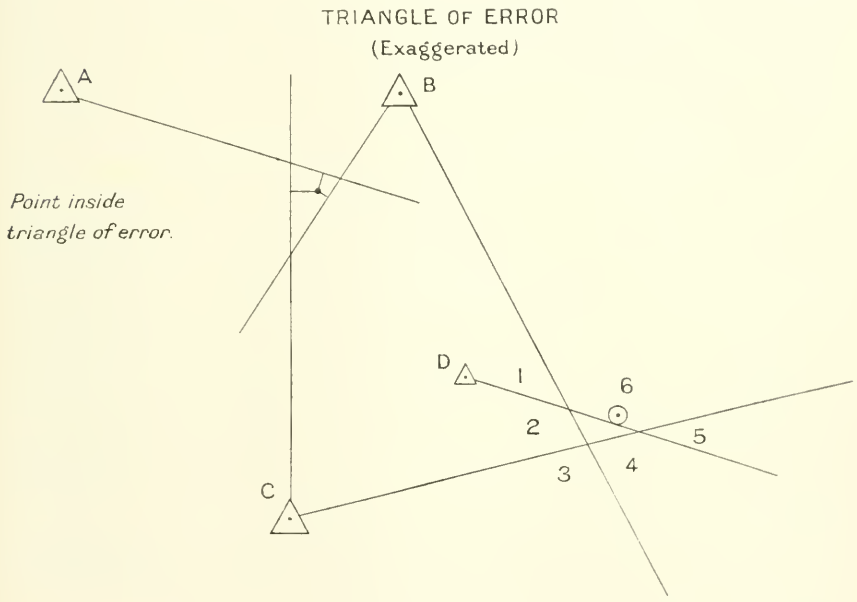
Do the same with the second fixed point, and the intersection of the rays gives the position on paper.

In no case should the angle between the rays be less than 60°; the nearer 90° the better the result, which, however, *is never reliable.*

If it is absolutely necessary to use this system, the fixing should only be used for sketching the surrounding detail, and *not for throwing out points on which future work depends.*

(b) *Interpolation from Three Fixed Points.*—The second system is

Fig. 17.



the commonest part of plane-table work, and is described by *Close* as follows:—

"Set up the plane table at any point from which three previously fixed points can be seen. These should be trigonometrical points, if possible [para. 6 (q)]. Orient the table roughly by the trough compass, and from the three fixed points draw back-rays If these three rays pass through a point, this point is the required position. If they do not pass through a point, the rays will form a small triangle, called the 'triangle of error.' The true position is now to be determined by the following rules [*see* Fig. 17]:—

"I. If the 'triangle of error' is inside the triangle formed by the three fixed points, the position is inside the triangle of error; and if outside, outside.

"II. In the latter case the position will be such that it is either to the left of all the rays when facing the fixed points, or to the right

of them all. Of the six sectors formed by the rays, there are only two in which this condition can be fulfilled.

"III. Finally, the exact position is determined by the condition that its distances from the rays must be proportional to the lengths of the rays."

In Fig. 17, for instance, the trigonometrical points B, C, and D were visible.

"By condition I. the point must be outside the triangle of error.

"By condition II. the point must be in sector 6 or in sector 3.

"By condition III. the point must be in sector 6, since the distances from it to the rays must be proportional to the lengths of the rays, and by estimation it will be where shown.

"Having thus determined the position, place the sight-rule along the line joining this and the most distant of the points used, set the sight-rule on the point by shifting the plane table; clamp and test on the two other points. If there is still an error (which should, however, be much smaller) go through the process again.

"The best position is inside the triangle formed by the three fixed points, of which two are near and one is distant. Accuracy of position is ensured by two points being near, accuracy of setting is ensured by aligning on the distant point. And, in general, fix from near points, set by a distant point.

"It is very necessary to be able to interpolate by this method both rapidly and accurately. *It is the essential foundation of all good topographical plane-tabling.* The plane-tabler in open country need not pace or measure a yard after he has fixed his base. In addition to the speed which results from a free use of interpolation there is also a gain in accuracy, since there is no piling up of errors, and each fixing is dependent only on the main intersected or other well-fixed points.

"There is one case in which the method fails, viz., that in which the observer's positions and the three points lie on or near the circumference of a circle. The plane-tabler should be on the lookout for this, and not interpolate from points so situated. [If there is any doubt, use a fourth fixed point if available. In no fourth fixed point, recourse must be had to the compass, as in (a)].

"*It will have been noticed that the trough compass is only used to orient the plane table roughly; the final fixing does not at all depend on the compass. It is important that this should be remembered.*"

210. Too much importance cannot be attached to clean, neat ray drawing, and the following rules should be observed:—

Drawing Rays and Keeping Field Note-book.

I. Always use the same edge of the alidade.

II. Rub out all rays at once the moment they cease to be of use with a *soft* rubber.

III. A sharp-pointed pencil of not too hard lead is essential, for too faint rays are apt to be lost and try the eyes; too thick rays are dirty and inaccurate, and too hard rays tend to destroy the paper when rubbed out.

IV. "When it is required to draw a ray from a point, put the pencil upright on the table with the edge of the wood end just touching the point, and lay the sight-vane against the pencil. Or instead of a pencil some expert plane-tablers use the finger. Pins should never be used."—(*Close.*)

V. "When drawing a ray from a dot set the point of the pencil into the dot first, so as to get the correct angle at which the pencil should be held when drawing it along the sight-vane. Without this precaution large errors creep in."—(*Close.*)

VI. Identify each ray by producing it to the margin, and give it a number or letter there in pencil.

VII. A complete page, or pages, must be kept in the field note-book for each station, headed by the name and description of the station. A sketch or diagram of the rays drawn from the station, with full descriptions of the points to which they were drawn, will be given. Full use must be made of numbers or letters to distinguish these points in the diagrams and descriptions. These numbers or letters will be the same as those entered on the field sheet. (*See* VI.)

VIII. Too great importance cannot be attached to this question of identification. It must be remembered that even the most prominent objects change their appearance when viewed from a less range, from lower or higher ground, or from a different direction.

Use of Survey Beacons in Plane-tabling.

211. (a) The rules given in para. 83 for the erection of survey beacons should be generally followed in plane-table surveys. The country being open, however, and a considerable number of trigonometrical points being already marked, less beacons are required than in the traverse survey of the forest belt. The camp officer, in fact, must use his discretion in leaving a reasonable number of beacons and bench marks in the area of his field sheet, remembering that these will be of great value in supplementary and revision surveys.

(b) As mentioned in para. 206 (e), beacons must be left at plane-table trigonometrical stations.

(c) Beacons, or bench marks cut into some permanent object close at hand and painted red, should be left at important cross roads, important stream crossings, towns, large villages, and on prominent hill tops. As most of the places mentioned are probably at or close to plane-table fixings, it is generally convenient to leave the beacon or bench mark at or close to the plane-table fixing.

Fixing Heights and Contouring.

212. In plane-table surveying heights are fixed and form-lines inserted by a combination of two methods, viz., alidade heights and aneroid levels (Tertiary Heights, para. 116).

(a) *Alidade Heights.*—The plane-tabler can obtain his height at any plane-table fixing by carefully levelling the plane table by means of the bubbles on the base plate, bringing his vertical arc bubble to the centre of its run, intersecting with the horizontal wires the nearest fixed point of which the height is known, and reading the vertical arc.

This point should be one of the trigonometrical points, and is usually one of those by which he has interpolated or otherwise fixed his position.

He then measures the distance in feet on the paper to this point and multiplies it by the natural tangent. The result is the difference of level in feet.

The result must be checked by repeating the process, using another trigonometrical point.

The calculation and entry of the vertical angle must always be made in the field note-book. *See* para. 210, VII.

The natural tangent can be taken out of Table X. For example, suppose the vertical angle is 7° 30′ and the distance 4230 feet.

The natural tangent for 7° 30′ = 0·13165.

Then the difference of level = 0·13165 × 4230.

4000 feet	. . . .	4 × 131·65 =	526·6
200 „	. . . .	2 × 13·16 =	26·3
30 „	. . . .	3 × 1·31 =	3·9
			556·8

Suppose, for example, that the vertical angle is an elevation, the height of the fixed point 1768 feet, and the height of the telescope axis above the ground is 3·2 feet, then the height of the plane-table fixing is—

$$1768 - 556{\cdot}8 - 3{\cdot}2 \text{ feet.}$$

The result, 1208 feet, is entered in upright brown figures on the right of the symbol denoting the fixing.

A good example is given in para. 214 (k).

(b) The plane-tabler, by reference to his field note-book, can ascertain whether the height of the fixed point is that of the cockshy to which he observed or that of the ground. If the latter, then he must further correct the result by deducting the height of the cockshy above the ground.

(c) *Number of Alidade Heights.*—A sufficient number of heights should be taken to give a good basis for contouring, and varies considerably according to the country. By "contouring" form-lines are meant.

Undulating country requires rather more heights than mountainous country, as the form-lines are more difficult to follow. Close country requires more than open, and skilled surveyors less than unskilled.

A good rough rule to follow is to take alidade heights at about two-thirds of the plane-table fixings. According to para. 207 (b), this will give, per 6 square inches of paper, from fifteen to twenty alidade heights in open country, and from thirty to forty-five in difficult country.

The surveyor, however, must use his discretion, and satisfy himself that he has sufficient alidade heights to make his aneroid heights reliable.

(d) *Contouring.*—Having determined the height of his plane-table fixing, the plane-tabler can now fix therefrom the heights of all the points around him, the positions of which he has plotted on his plane table. These points may be the junctions of roads, streams, prominent rocks, etc. A rock or tree lying at, or close to, some sudden change of slope in a spur, or on a hill across a valley, is a useful point of which to fix the height.

Having entered the heights of these points on his field sheet he is able, if he has fixed a sufficient number, to put in the form-lines near them in pencil by eye, even if he is half a mile away. Later, when

he actually visits these points, or some of them, he can complete the form-lines.

(e) If the plane-table fixing is on a fairly uniform slope, he can sketch the form-lines of the hill he is on by observing the slope with his alidade, and taking the H.E. (Horizontal Equivalent) for the difference of level between his position and the form-line from the following table :—

TABLE OF HORIZONTAL EQUIVALENTS.

For Vertical Interval of 50 Feet.

Degrees.	*Feet.*	*Degrees.*	*Feet.*	*Degrees.*	*Feet.*	*Degrees.*	*Feet.*
1	2865	6	477	11	261	16	180
2	1434	7	408	12	240	17	168
3	954	8	360	13	222	18	159
4	717	9	318	14	204	19	150
5	573	10	288	15	192	20	144

For Example.—Suppose the height of the plane-table fixing is 740 feet and the slope is 9 degrees. The 700′ form-lines will be $\frac{40}{50} \times 318$ feet away from him, *i.e.*, 254 feet. Similarly the 750′ contour will be 64 feet from him, the 800′ contour will be 318+64 feet, etc. The calculation must be made in the field note-book, para. 210, VII.

This system holds good as long as the slope is uniform. Hence it follows that it is valuable to have the plane-table fixings at, or to know the heights of, the points where hills change their slopes. The value of fixing heights on opposite hill sides, as in (d), is thus shown.

(f) *Use of Aneroid.*—It would be a tedious, slow process to sketch the form-lines completely by alidade heights as described in (d) and (e). The plane-tabler can therefore combine the use of aneroid and alidade with advantage.

The usual way in which the form-lines are sketched by aneroid is by aneroid levels, run as described in para. 116 (m) between alidade heights. It is, however, not always necessary to follow the system exactly, as the following examples will show :—

Example A. Using Aneroid without Correction Chart and without Closing.—The aneroid can be set at the known height of the plane-table fixing and read at the changes of slope or other points in the vicinity, without using either the correction chart or closing, provided that—

I. Readings between 8.30 and 10 A.M. and between 2.30 and 4 P.M. are not longer than an hour from the time the aneroid was read at the plane-table fixing.

II. At other time, not longer than half an hour.

It is safer, however, to close on the original starting-point if convenient.

Example B. Not using Correction Chart.—A typical example of the use of an aneroid without correction chart is when a plane-table fixing is on a hill top and the side of the hill falls in irregular slopes covered by scrub, etc., to the bottom of the valley where a height has been fixed at a point A. The scrub prevents the plane-tabler seeing the bottom of the valley. He sets his barometer at the height of the plane-table fixing (say 690 feet), paces down the hill until the barometer reads about 660′, halts, and gives it time to settle, when it will probably drop to 650′ (if it does not he must go lower), enters the distance paced in his field note-book, continues pacing to about 610′, etc. On arrival in the valley he compares the aneroid and alidade heights of the known points A, and adjusts, if necessary, his aneroid heights. The total length of his pacing, reduced to the horizontal, should equal the distance between the plane-table fixing and A. It is seldom worth while to reduce this mathematically; in the majority of cases the surveyor can do this by estimation, especially if he has adopted the length of his pace to each change of slope.

It will be seen that the wave correction could easily be applied in Example B. It is seldom worth while to do this if the aneroid level does not cover more than an hour or two, as the close localises any error. It is, however, very necessary to use the chart when the level covers a longer period than two hours.

Summarising, it may be generally accepted that alidade heights are sufficiently numerous to permit of the use of the correction chart being dispensed with, and to give opportunities of closing aneroid levels in a reasonable time.

Example C.—Another and very useful way of using the aneroid is thus described in *Close*. It will be noticed that the use of the wave correction chart will considerably lengthen the time that can be allowed to elapse between starting and closing.

"In using the barometer to determine the approximate positions of contours, it is necessary to work between points of which the heights have been previously fixed. Thus, supposing the height of the top of a hill is known, and also a height in the valley below; at the lower station set the instrument to the proper height, move up along any convenient spur, stopping where the barometer reading shows the required contour levels, fix these points on the plane table, sketch in the neighbouring features, and close on the top of the hill. If the reading differs from the known height of the top of the hill, a proportionate correction must be made to all the contours drawn in. It is desirable that the distance between the fixed heights should not, as a rule, exceed a few miles, and it is clearly necessary that the elapsed time between starting and closing should be as short as possible."—(*Close.*)

The aneroid is very useful in fixing the height of points immediately around the plane-table fixing. This can be done by the assistant while the plane-tabler is fixing his own position, heights, etc.

Aneroid levels are run in the usual way when a plane-table traverse has to be run through a patch of forest. The level can be closed on the alidade or other fixed height at each end.

(g) *Fixing an Alidade Height from another Alidade Height.*—This should be done as rarely as possible. In broken country, however, it is not always possible to avoid it. It follows, therefore, that the height of plane-table fixings, obtained as described in (a), should be checked by using two trigonometrical points, so as to be more valuable as a basis for the heights of other plane-table fixings.

(h) The *Indian Handbook* advises that plane-table fixings should first be placed on high ground, and afterwards on low ground. The advice is so valuable from the point of view of contouring that, although it concerns plane-tabling generally, it is given here.

"In hilly country, it is best to commence work from the tops of the hills, and work downwards rather than *vice versa*, as not only is the extent of country visible from high ground, over which rays to detail can be drawn, much greater than from the valleys, thereby necessitating the setting up of the plane table fewer times to complete the survey of a given area; but from high ground, the different topographical features assume a far truer relative value than they ever will when looked at from below. There is also the further advantage in working from high ground, rather than from below, that when making a fixing from which a comparatively extended view is obtainable, the chances of seeing the number of trigonometrically fixed points necessary for a good plane-table fixing are greater than they would be were the fixing made on low ground.

"For much the same reason it is always best to survey a slope, as far as possible, from two or more fixings high up on an opposite hill, rather than from those on the slope itself. There will, of course, always be the necessity of making fixings on the low ground, and on the slopes under survey, in order to survey detail which it has been impossible to obtain from the higher and more distant fixings; but their number will be comparatively few, and their attainment, owing to the number of good plane-table points which will already have been fixed in their neighbourhood, a matter of comparative ease.

"Another point which it is worth while remembering is the importance in regular work of guarding against the tendency to *waste time by drawing rays to distant objects whose position will be more easily fixed later on by shorter rays. The drawing of an excessive number of rays from one fixing leads to confusion on the plane table, and occupies time which would be more usefully employed in making a second plane-table fixing elsewhere*, and again drawing a moderate number of rays from that. This does not apply to reconnaissance survey, or survey carried out during military operations in a hostile country, where the freedom of movement of the surveyor will always be restricted, and it is consequently of the utmost importance to get all detail fixed, even approximately, whenever and wherever the opportunity may offer."—(S.I.)

213. A patch of forest or scrub occasionally necessitates a traverse being run. The following are the methods employed.

Plane-table Traverses.

(a) *Secondary Plane-table Traverse.*—Start at the nearest plane-table fixing and orient the board. Send a man with a banderole as far forward as possible and draw a ray to him. Chain up to the banderole, set by the back ray, and draw a ray to the next station. The compass is not used.

Ordinary single chaining will do, and every effort should be made by clearing to get rays of at least 300 feet.

The traverse must be closed on the trigonometrical survey on emerging from the forest as soon as possible This is done either by closing on a plane-table fixing or by turning the last station of the traverse into a plane-table fixing.

Heights are taken by aneroid level in the usual way, para. 116 (m).

Village and river field books are kept in the usual way. A barometer field book may be kept in which to enter the number of the station and the reading and correction of the aneroid, but this can be saved by entering the *corrected* reading in pencil at each station on the auxiliary sheet, making any further correction found necessary when the aneroid level is closed.

(b) *Primary Plane-table Traverse.*—The foregoing constitutes what is called a secondary plane-table traverse and is usually all that is required.

If great importance is attached to the survey of some particular track a primary plane-table traverse should be run. This only differs from a secondary traverse in that double chaining and a Close-Brooker alidade is used. Alidade heights are also carried through.

(c) Primary plane-table traverses are of great value in surveying a coast line bordered by scrub, or railway lines running through a forest, as long rays are usually obtainable. If due care is observed, azimuths observed every 5 to 10 miles, average rays of 2000 feet obtained, and latitudes observed for purposes of adjustment about every 25 miles, the traverse should not be more than about 1 : 750 to 1 : 1000 in error.

(d) *Tertiary Plane-table Traverses.*—These are run in the same way as a secondary plane-table traverse, except that the board is oriented at each station by the trough compass and is not "set" by the back ray. A tertiary plane-table traverse is, in fact, practically a tertiary compass traverse as described in para. 104, but has the great advantage of doing away with all keeping of field books except those for villages and rivers, and possibly one for the aneroid levels.

(e) In practically all cases an auxiliary sheet should be used for the traverse. The scale should be of suitable size to plot the rays at least 0·2 inches long, *i.e.*, if the average ray is 1000 feet, use scale 1 : 62,500 ; 500 feet, use scale 1 : 31,250 ; less than 500 feet, use scale 1 : 12,500. The auxiliary sheet can be reduced to the field sheet when the traverse has been closed.

Examples of Plane-table Survey.

214. (a) In this paragraph examples illustrated by Fig. 18 are given of plane-tabling. It is by no means insisted that the examples are perfect, nor that they represent the only way of doing the work, but they form a good guide to the methods which should be employed.

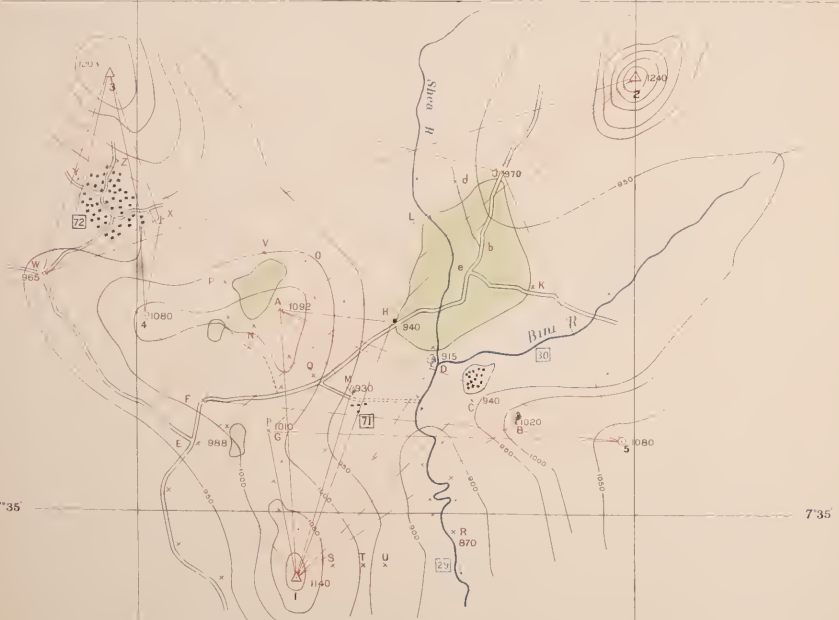
Note.—A far larger number of plane-table fixings would be made on an area such as shown to fill in the details of the country. Only a certain number of details and fixings are given in order not to confuse a drawing made for purpose of explanation.

Many more examples might be added, but plane-tabling varies so much with the nature of the country that it would serve no useful

Fig. 18.

EXAMPLE OF P. T. SURVEY

Scale - 1/62,500



purpose to multiply them. Every knoll, every tree clump, every rounded slope, makes a difference in the methods employed. The topographer is not made from examples; they put him in the right way, after which a day in the field is worth a dozen pages of print.

(b) Fig. 18 represents part of a field sheet, scale 1 : 62,500.

1, 2, 3, 4, 5 are the reference numbers which the surveyor has plotted on his field sheet from the triangulation chart. They represent three trigonometrical stations and two trigonometrical intersected points. A full description of their appearance, locality, height and co-ordinates are in the surveyor's field note-book, each opposite its respective reference number.

These, their heights, and the graticules are all that are on the sheet when the surveyor commences work.

The red letters on the map are merely used as temporary distinguishing marks and are not inked in. The names of the rivers are given on the plate for reference sake; their reference numbers (29 and 30) only would be shown on the field sheet.

(c) *Choice of Starting Point.*—The surveyor selects a trigonometrical station as his starting point, as he knows he will get a good view from there. He chooses Station 1, selecting the village near M as his camp. 71 is the reference number of this village.

(d) *Preliminary Work.*—The afternoon before he sees that all stores are ready, such as banderoles, a steel band in case chaining is necessary, plane table, alidade cross-hairs all right, aneroids in order, matchets and axes in case any clearing is wanted, field note-book and river and village field books in his haversack, survey umbrella in repair. Arranges to be called at 5, breakfast at 5.15, leave camp at 5.45, and lunch to be sent out by 11 A.M. Also for his men's food to be sent out, leaving one man in every ten in camp to prepare and bring it out. The plane-tabler will find a light chair and table of great use.

(e) *Suggested Plane-table Party*:—

1 Headman.
Pupils (if any).
5 intelligent Banderole Men, each with two banderoles and a matchet.
1 Plane-table Boy, with aneroid and binoculars sling.
1 Boy for chair, table, umbrella and haversack.
1 Boy with paint and brushes, cold chisels, hammer, saw, nails, wire, light hand-axe and matchet.

(f) *Preliminary Inspection.*—This may have been carried out on the previous day. At Station 1 the plane-tabler makes a thorough inspection of the country with his binoculars and resolves to divide it into sections as follows, and to complete each section as far as possible before going on to the next:—

Section I. The country on each side of the line 1 – 4.
Section II. The country on each side of the line 4 – 3.
Section III. On each side of the line 3 – 2.
Section IV. On each side of the line 2 – 5.
Section V. On each side of the line 5 – 1.

(g) He notices, however, that the general shape of the ridge hides the valley of the Shea River from an observer at 4 and, as it is advantageous to get plane-table fixings along high ground to begin with, he selects a hump at A and sends his headman forward with a banderole to obtain a position for a plane-table fixing which will give a good view of the valley.

(h) He sets and tests plotting as described in para. 205.

(i) Draws rays to the following prominent objects :—

B. A tree near which a marked change of slope occurs.
C. A rock near a large patch of cultivation.
M. A prominent tree near the village.

Enters description of these points and a diagram on a page of his field note-book, which he heads "Trigonometrical Station 1," and keeps another page blank for future entries from that station. *See* para. 210, VII.

(j) He then proceeds to A, sets by the back ray on 1, interpolates his position by a ray from 5, and checks it by a ray from 2, as in para. 208. Starts a page for A in his note-book.

(k) Fixes his height, as described in para. 212 (a), from 1. The result is 1082 feet. He checks it by a ray to 5 and gets 1102. The discrepancy is so great that he checks by 2 and gets 1104. This is unsatisfactory, so he refers to the description of 1, 2 and 5 in his field note-book and finds that the height of the ground at 2 is given, whereas he observed to the cockshy, 12 feet above it. Subtracting this from 1104 he gets 1092, a satisfactory mean between the results from 1 and 5.

(l) *Intersections.*—From A he draws rays to B, C and M. E and F are two bends in the road which he has noticed on his way from 1 to A, and to which, as they have no prominent object to mark them, he sends banderoles, as he believes they can both be seen from 1 and A. From A, however, he finds he can only see F, so he draws a ray to F.

He also draws a ray to H, a hut where the road enters the forest. From A he can see a short ridge of rocks where the Bini joins the Shea. Draws a ray to D, a palm tree about 100 yards from this ridge.

(m) Having intersected these points he works back along the ridge to 1, interpolating his position every 200 to 400 yards. Only one of these interpolations, that at G, is shown in detail in Fig. 18. He gets his plane-table fixing at G by rays to 1, 2 and 5 (Station 4 happens to be invisible). Fixes his height by rays to 1 and 5.

From G he intersects B, C, D, H, M and F, and draws two rays tangent to the wood on his west. [Rays omitted in Fig. 18 for the sake of clearness. Reason for drawing rays tangent to the wood is given in subpara. (r)].

The slope to the east being uniform, he gets the position of the 1000′, 950′ form-lines as in para. 212 (e). To the west he sends one of his pupils to pace to the north-east corner of the wood and take its height by aneroid. He is thereby enabled to plot that corner approximately ; it can be checked later.

Fixes height of F, as he has now obtained three intersections of it, from A, G, and another fixing between A and G.

He adopts a similar procedure at the other plane-table fixings on his way from A back to 1, but does not intersect all the points B, C, D, etc., from every fixing; it is sufficient if each point is fixed by intersection from three fixings.

(n) *Having got back to* 1 he intersects D and H, which, on his first visit to 1 he had not considered worth intersecting until he had found their value when at A. He finds that he can see E from 1, but not from any of his other fixings on the ridge 1 to A. He draws a ray to E. (*Note.*—He goes to E later and makes a fixing there by setting on the ray E to 1, and using the points 2 and 4.)

Having now numerous points fixed by at least three intersections (one each from 1 and A, and the third from G or one of the other plane-table fixings along the ridge) he proceeds to fix the height of a sufficient number of them to allow of putting in form-lines. For example, finding the height of B to be 1020 and C to be 940 he interpolates by eye the form-lines between them.

Note.—The heights of B and C can be checked if the surveyor has observed their vertical angles with the alidade when at A or G, and entered them in his note-book.

(o) *Contouring.*—The slope. The slope east of 1 is very irregular, so he walks down it, stopping at S, T, and U to make three plane-table fixings, each close to a prominent object, and a fourth plane-table fixing at R. Around S, T, U and R he puts in the topographical detail. It is not necessary for him to fix alidade heights at all three points, S, T, U. If he fixes the heights T and R by alidade he can get the heights of S and U and the positions of the form-lines by an aneroid level. The heights of R and D enable him to show where the 900-feet form-line crosses the stream, for, except where falls occur, the drop of a stream is uniform.

(p) *River Survey.*—The plane-tabler would now probably walk up the valley, making sufficient fixings to determine the course of the river by interpolation to some of the trigonometrical points, and to his two very useful banderoles at A and G, the rock at C, tree at B, etc. At each fixing he sketches all surrounding detail. With regard to the river he follows the general rules given in para. 72, but it would only be necessary to give one reference number and one page of description in the river field book.

(q) *Villages and Towns in Plane-table Surveys.*—The general size of these can be ascertained and the perimeter plotted sufficiently accurately by drawing tangent rays. For example, the shape of the town No. 72 is determined by tangent rays drawn from 3, 4, W, and V, and the fixings mentioned below. The position of any prominent building, such as the mosque or mission, or of the Commissioner's flag staff at X, are fixed by intersection. A plane-table traverse, or a compass traverse, can then be run by the assistant along the principal streets, closing on X and on plane-table fixings at Y and Z. The general rules for the survey of villages given in paras. 71 and 117 (l) to be adhered to, town being surveyed by the assistants on the 1 : 12,500 scale with a view to suitable reduction for marginal plans.

(r) *Plane-table Survey of a Forest Patch.*—The edges of small woods can be determined by tangent rays. For example, the small wood between E and G can be fixed by tangents from 1, E, G, and

N. A couple of plane-table fixings may be made near this wood for contouring purposes.

The wood near A is surveyed by means of the five plane-table fixings, A, N, O, P, and V.

The large wood south-west of 2 is surveyed by plane-table fixings at H, L, J, and K. Plane-table traverses are also run along the roads and closed on the fixings. A rope partal is made of the river, and a rope traverse of the path b-d, all closing on plane-table fixings.

(s) *Roads and Paths.*—These are not chained The plane-tabler makes plane-table fixings at important points on them, such as bends, hill crossings, and river crossings, and arranges that other plane-table fixings, which he uses for other purposes, shall also be on or near the road. The road is then put in by eye. Many points on it can also be obtained by intersection of trees, etc., on or close to the road.

For example, the road from E to J is surveyed by plane-table fixings and intersections as far as H, and thence by plane-table traverse to J.

(t) *Survey Beacons.*—He probably leaves survey beacons in the usual way at e, A, and E. Bench marks in town 72 in about three places, and one in village 71.

215. (a) No intersected point should be considered as satisfactorily determined unless fixed by rays from at least three plane-table fixings.

Summary of Hints, Plane-table Surveying.

(b) A plane-table fixing should be made from trigonometrical points, but when none are visible three previous plane-table fixings may be used provided that each has been fixed from three trigonometrical points, and that *its position is inside the triangle* of the three plane-table fixings. Every effort must, however, be made to avoid using plane-table fixings only.

(c) Work along the high ground first and then the low ground.

(d) The sun in front of the plane-tabler throws up hill features in strong relief, the sun behind him makes them blurred.

(e) Do not draw rays to distant points that can just as well be sketched later on from close at hand.

(f) Rub out rays that have ceased to be of use, and letters that have been temporarily used to distinguish plane-table fixings.

(g) Do not rub damp paper; let it dry first.

(h) Keep the sheet clean and neat, and make the reference numbers plain. Ink in all detail that is fixed as soon as possible.

It is advisable to take out ink and colour to do some of this at the midday meal. Anyway, it should be done that evening at latest.

(i) Plan the programme of work before hand. It does not follow that it cannot be altered, but a good plan of campaign doubles the rate of work.

(j) Arrange camps so as to require as few shifts as possible.

Days on which camps are shifted should not stop work if the surveyor takes a smaller plane-table party with him and arranges for the remainder of the men to make a double journey. A shift

of 7 miles can be managed this way (Table VII., para. 52), and it is advisable that tents should be among the first loads sent. If a longer shift is necessary, half-a-day's work is generally possible; at any rate the preliminary inspection mentioned in 214 (f) can be carried out.

(k) Keep the field note-book clear and distinct. A separate page (or pages) is to be kept for all the information gathered at each point visible, and the page is to be headed with the name and description of that point.

CHAPTER VII.*

TRIANGULATION.

Triangulation the Basis of Topographical Surveying.

225. THE only safe basis for topographical operations is beyond all question a system of accurate triangulation, whereby undue accumulation of error is precluded in the extension of the work and at the same time limits are set to the intrusion of error in the internal details. For topographical purposes, all data of the main triangulation of Southern Nigeria must be considered errorless, but "intersected points" fixed by long rays for temporary topographical purposes should be rejected as soon as the same points have been well fixed by triangulation from near stations by topographical parties. In the case, however, where a heliograph has been put over a mark on the intersected point and observations have been taken from two or more principal stations, those intersected points should also be considered errorless. Wherever stations are found, the initial elements required for commencing a survey are available, viz., the latitude, longitude, and height above sea-level of a fixed point, a base of ascertained length, and an initial azimuth.

Classes of Triangulation in Southern Nigeria.

226. (a) The main triangulation of Southern Nigeria corresponds approximately to the nature of the "secondary triangulation" described in Close's *Topographical Surveying*. The triangular error is not to exceed 6". The sides of the triangles to be about 10 to 40 miles. The triangulation to be executed with a 6-inch theodolite.

(b) The minor triangulation corresponds to Close's "tertiary triangulation," and is used to break up the main triangulation into triangles from 1 to 10 miles' side, and to extend the framework of the map into the forest belt along the narrow tracts of open country which occasionally occur. The triangular error not to exceed 15". The triangulation to be executed with a 6-inch or 5-inch micrometer theodolite.

(c) Plane-table triangulation is used in very broken country to break up the main or minor triangulation. It is executed with a plane table and telescopic alidade (Close-Brooker pattern).

(d) The main triangulation, and in most cases the minor triangulation, is carried out by the Trigonometrical Section, Topographical Branch. The remainder of the minor, and all the plane-table, triangulation by the Field Camps, Topographical Branch.

* This Chapter is adapted to meet local conditions from the Chapter on Triangulation in the "Indian Handbook."

SITE FOR TRIG STATION IN MANGROVE SWAMP

CLEARING TRIG STATION, MANGROVE SWAMP.

No1 FIELD CAMP. MINOR TRIANGULATION OF LAGOS LAGOON

227. Trigonometrical points are either "stations of observation" where a theodolite is set up, or intersected points which are unvisited and fixed by two or more rays from stations of observation. The size of the triangles and the number of fixed points per square mile must depend on the scale of survey, *the nature of the country, and state of the atmosphere at different times of the year.* The larger the triangles, the greater the rapidity of covering the ground, and the simpler the computations. All consideration of scale may, however, be got over by regulating the number of points to be given on a certain area of the paper on which the final survey is made, instead of on a certain area of ground. A good estimate is one trigonometrical point on the average to each 6 square inches of paper, *i.e.*, about 4 inches apart.

Number of Trigonometrical Points Required.

228. (a) It is indispensable, in order to get the best results from a theodolite, that it should be placed on a perfectly stable foundation; and on marshy ground a certain amount of building is sometimes necessary to ensure this. The ordinary procedure is to build with bricks (or stone) set in cement a central pillar as high as is required and on a good foundation, just large enough to accommodate the theodolite stand, say 2 feet 6 inches in diameter. In the centre of this, on its upper surface, an iron pin is let in, on which are engraved crossed hairs, to mark the exact site of the station, forming the "station dot." Around this pillar, but not touching it, is built a rough platform of wood or stones and mud, on which the observer stands when at work; the space between the pillar and platform, and which may be about 2 inches wide, is filled in with loose grass or sand. The stations are generally built during the time that the reconnaissance is in progress, so as to be ready for use when the angular measurements begin, and at the same time polemen are sent out with instructions to fix up signals on various conspicuous points previously selected by the triangulator.

Construction of Stations.

(b) In "minor" triangulation building is very rarely necessary, and stations are placed on solid rock, or merely on the ground surface. In the first two cases it will suffice to engrave the circle and dot *in situ*, but otherwise it should be done on a large stone subsequently embedded in the ground, or cross hairs should be engraved on an iron pin set in a stout wood picket of not less than 6-inch diameter. On marshy soil, or in other circumstances where the ground is very unsteady, an excellent temporary support for the theodolite may be made by driving deep into the soil three large stakes on which the legs of the stand will rest.

(c) In flat country where there is much low scrub it is often convenient to build a platform, but great care must be taken to construct it in two separate parts, the central one for the instrument, the outer one for the observer. If these platforms are well designed and well constructed, there is no difficulty in raising the telescope of the theodolite to a height of 15 feet above the ground.

(d) Over each station a beacon, or "cockshy," is erected to act as an opaque signal in dull weather, and as a shelter to the observer and his instruments. These beacons are four-legged for main stations

and three-legged for minor. Such material as the neighbourhood provides will be utilised, all lashings of wire or stout rope, and each leg must be secured with a cairn of stones of at least 3 feet in height, these stones resting on the lower bracings. A thatch of grass or palm leaves, and pole and white flag, complete the cockshy. (*See* Fig. 19.)

The greatest care must be taken in centering such beacons over the station dot, and the plumbob should be hung in prolongation of the axis of the flag-pole at the point where it leaves the beacon proper to ensure this.

The dimensions should be in accordance with Fig. 19.

The greatest care should be taken to clear all grass and scrub for a distance of 30 yards around each cockshy to prevent destruction by bush-fires in December to February.

229. Before commencing the actual observation of the angles of the triangles a previous reconnaissance with the plane table is necessary, by which the most advantageous positions for the stations are chosen, and points selected for the erection of temporary signals, such as poles, flags, etc., where natural objects are wanting. In skilled hands this rough reconnaissance may become a very fair approximate map of the country, and will repay a large amount of care and thought bestowed upon it. The identification of the so-called "intersected points" when observed from two or more stations depends largely on the clearness and accuracy of this preliminary work; moreover the selection of "well-conditioned" triangles is much facilitated by it, and it is of use in many less obvious ways which a surveyor soon learns to appreciate.

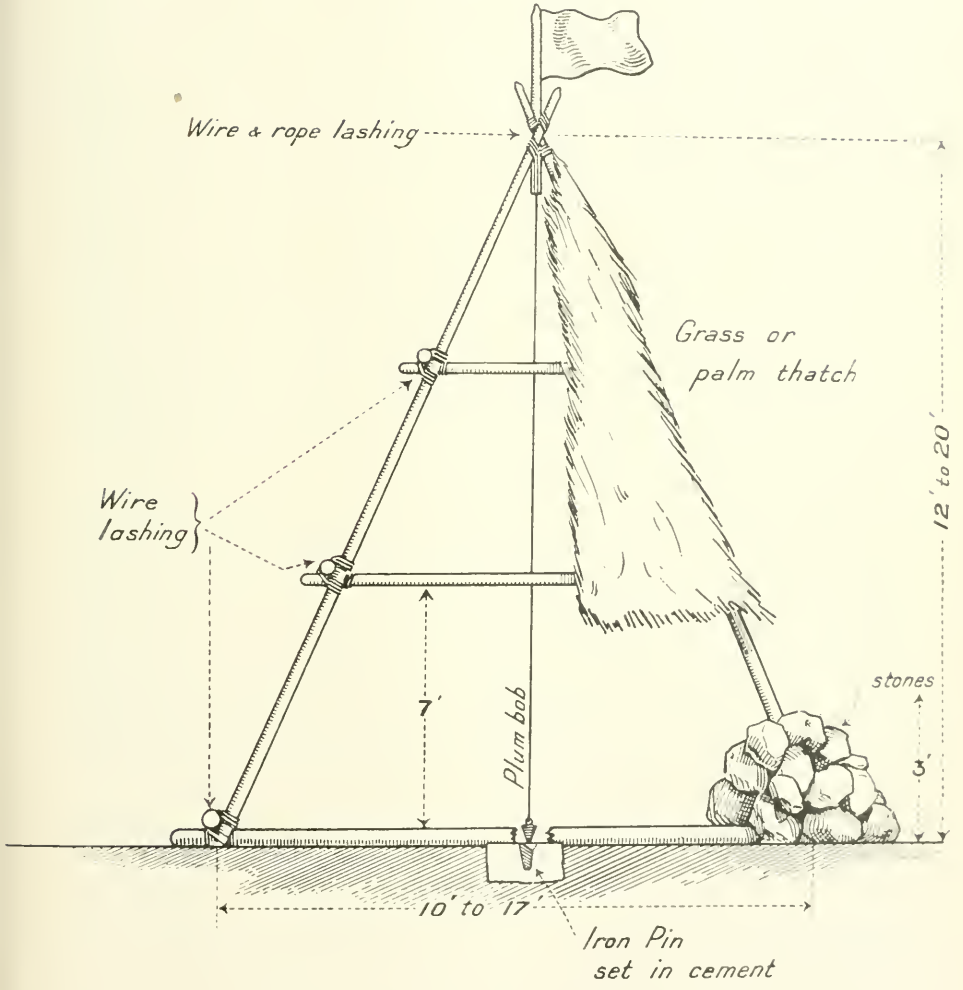
Reconnaissance Chart, and its Use.

A field chart of triangulation should be projected so as to include the area allotted to the triangulator, and all previously ascertained trigonometrical points therein plotted thereon, the trigonometrical stations and rays being inked up in red and the intersected rays and points in black. A scale quarter of that of the detail survey will generally be found suitable, *i.e.*, 1 : 250,000.

In selecting points to be fixed the triangulator must imagine himself in the position of the plane-tabler about to survey the ground in question, and such points must be chosen as will facilitate the plane-tabling. A triangulator is too apt to fix points on the hills to the exclusion of those in the valleys, whereas if the valleys are narrow and confined points with heights low down in the valleys are of the utmost importance to a plane-tabler. In very rough mountains points can be sometimes fixed down slopes, and in positions where intersection is impossible, by means of the bar-subtense method. This will give points with quite sufficient accuracy for plane-tabling purposes up to distances of 1½ to 2 miles.

In commencing his reconnaissance, the triangulator, accompanied by several of his polemen, who will subsequently have to pole the points, should first visit one end of his proposed base, examining the ground as he goes for suitable points to be used as intersecting points. He should interpolate his position on the plane table as opportunity offers by means of such points as he has plotted, so as to take rays to, and fix the position of, intersected points, which,

FIG. 19
QUADRUPOD COCKSHY



if necessary, should be there and then poled by sending men off to put them on hills or trees. On reaching the station he should search carefully for such points on high ground as appear suitable for stations of observation, getting cross rays to them, and so approximately fixing their position as soon as he can. He should then make his way to the other end of the base, cutting in, poling where necessary, and naming or numbering intersected points as he advances. From the second station he will be able to fix approximately the positions of his forward stations of observation. He should then march towards one or other of these fixings, poling suitable intersected points *en route* as before. The new station should be visited, its position carefully fixed, and the site prepared when necessary, the mark-stone being cut and imbedded, and orders issued for the felling of trees, etc., in the direction of the rays required. After a little practice good headmen can be entrusted with the preparation of the sites after they have been visited by the triangulator and the necessary work determined on. When no forest exists this work is of the simplest, a little levelling of the ground and the placing of a mark-stone with pole and brush supported by a cairn of stones is all that is required. It cannot, however, be too much insisted on that the pole must be most carefully placed vertical and central over the mark-stone. If headmen see that their officer is always very careful about this point they soon get into the habit of very careful centering; this is most essential as the accuracy of one's work is entirely dependent on the faithfulness with which they centre the poles or heliographs, and there is no check on it. The work, however, should usually be done by European or native surveyors.

When a wooded hill is cleared to make a site for a station a conspicuous tree should be left standing somewhere near the station. In selecting such a tree take care that it is not so placed that its shadow will fall on the station and so interfere with the heliograph there. Such a tree will be of far more use to the plane-tabler than the pole on the station itself.

The whole ground is thus gone over, the officer marching from place to place as best suits the lie of the country, always keeping a careful plane-table reconnaissance of the work, choosing suitable points for intersection, and marking them by poling where necessary. The chart should be kept up to date, stations of observation and intersected points being inked in the correct way, and their names or numbers entered in ink. The lines connecting stations which are intervisible should, however, be left in pencil till the observations have been taken. It is necessary to keep a descriptive list of all intersected points fixed on the chart to facilitate their subsequent identification. This should be done in a note-book labelled "triangulation reconnaissance."

Care should be taken to avoid covering the board with a mass of pencil rays to doubtful intersected points which will only confuse the triangulator when he commences to observe. The intersected points selected should be definitely fixed and named or numbered, and tentative pencil work cleared off the chart. In this way, when the officer has reached the farther limit of the area allotted to him, he should have been all over the ground and selected all his stations of

observation and intersected points, all marked in their proper positions and named on the chart; he will then be ready to go back over the work taking the observations. The observer will, however, generally find it advisable to devote a little labour to the chart before beginning to observe with the object of avoiding unnecessary work afterwards. It will usually contain many redundant rays, and possibly some superfluous stations, but by distinguishing the different classes of triangles by different grades of pencil lines such rays as are unnecessary can be detected and cut out.

Without a preliminary reconnaissance, such as has been described above, it is impossible to carry out a successful triangulation.

On commencing to observe at any station a triangulator has only to fix his plane table truly in position, and write down in his angle book the list of stations and intersected points to be observed. By laying his plane-table rule on the line to any point, a careful search with a telescope or pair of binoculars will enable him to identify the object if it is in view.

As soon as reciprocal rays have been observed between stations of observation ink up the lines on the chart joining the stations with lines of varying thickness according to the class of triangles, and then go over the chart with the angle book and ink in the rays from the observing stations to each intersected point, inking up for clearness' sake only the last $\frac{1}{2}''$ of the line nearest the intersected point. A cross mark should be drawn across the line where a vertical angle has been observed. At the close of the field season this chart should be in such a state that any officer conversant with such proceedings would be able to lay out from it the computations.

All such charts should be bound up with the computations of a season's work.

Signals.

230. (a) Signals are of two kinds, luminous and opaque. The former consist of heliographs, heliotropes, and heliostadts, for use by day, the first named being the most satisfactory, and lamps for night work. Lamps are very useful in the main triangulation. Great care must be taken to centre the light accurately in the line joining the station dot to the point from which observations are being taken.

The men employed on heliographing must be carefully instructed to move from station to station in a certain order when they are no longer required at a particular station, as delays owing to cloudy weather and misunderstandings are apt to occur even with carefully trained men.

(b) The "cockshy," described in para. 228 (d) acts as an opaque signal; and a very useful signal for intersected points is that known as the pole and brush. This may be erected either by heaping up a pile of stones 5 or 6 feet in height around it, or by tying it on to the top of a tree. A rough coat of whitewash over the pile of stones will enable it to be seen much more readily against a dark background. When a tree is poled it is very necessary to have a mark, such as a triangle, cut deep into its trunk for future identification, or else to heap a pile of stones round its base.

(c) Another very good form of opaque signal is made of thin lathes

of bamboo worked into the shape of a deep basket. Two of these are joined together mouth to mouth and fastened on to a pole running lengthwise through them. The pole is supported by three other poles with forked ends leaning against it and firmly fixed in the ground, the intervening spaces between the supports being interlaced with split bamboos. This signal, when new, is very clearly visible at long distances.

(d) There is no better signal than a single tree or bush left standing on a hill-top from which all contiguous jungle has been removed.

(e) Small pyramidal tents may, under certain circumstances, form good signals, especially when looking down from a hill upon a plain below, but they are not often employed. Flags are very useful in forest-clad countries, and are easily recognised against a background of foliage where any other sort of opaque signal would be invisible. They are, however, apt to be stolen, and in calm weather are sometimes difficult to recognise.

(f) For "intersected points" natural objects should be used as much as possible; not only are they permanent, but are sure to be identified by the plane-tabler when at work. Isolated trees, etc., make excellent points, and for 1-inch work it is rarely necessary to pole or flag them. Rays taken either to the trunk, or to the apparent centre, of a tree are sufficient, provided there can be no doubt in the mind of the plane-tabler as to which tree amongst others has been intersected.

(g) For further signals *see Close*, page 10 and *School of Military Engineering Notes*.

Luminous Signals.

231. (a) *A heliograph* consists of a plain circular mirror, mounted on a tripod so as to be movable on two axes, one vertical and the other horizontal, whose directions pass accurately through the centre of the mirror, at which point a small black mark, about one-tenth of an inch diameter, is placed on the glass. Each heliograph is furnished with a sight-vane carried on a bracket arm, which can be turned and clamped independently of the mirror.

(b) The mirror is accurately aligned between the station dot and the observer's position, *i.e.*, the point to which a light must be shown, and the mirror roughly faced towards him. The sight-vane is then moved about, until, on looking into the mirror the observer's position, the cross hairs on the sight-vane, and the central dot of the mirror are seen to be coincident. The sight-vane is now carefully clamped, the mirror turned horizontally and vertically, until the sun's rays are reflected on to the sight-vane and the shadow of the black dot coincides with the cross hairs of the sight-vane. The mirror is then reflecting the sun's rays direct to the observer. As the sun alters its position the dot will travel off the cross hairs, and to preserve a steady light the lightman must see that he constantly adjusts his mirror by means of the tangent screws to prevent this.

(c) *Use of Duplex Mirror.*—It may happen that it is impossible to reflect the sun's rays upon the sight-vane, when aligned. Recourse must then be had to the duplex mirror, which is mounted on a frame which fits into the sight-vane bracket, and allows of adjustment in a vertical plane to the mirror.

The mirror is fitted with a piece of white paper, bearing cross hairs intersecting at the centre of the glass.

To set up, the duplex mirror is aligned on the observer, the tripod mirror being turned towards the sun. The duplex is then turned on its two axes, until the observer's station, the dot on the mirror, and the cross hairs on the duplex, are coincident. The tripod mirror is then turned as before, until the shadow of its dot falls on the cross hairs.

(d) *A heliotrope* consists of a plain, circular mirror, so mounted on three foot-screws, as to be movable on two axes, one vertical, the other horizontal, whose directions pass accurately through the centre of the mirror, at which point a small hole of about one-tenth of an inch diameter, is drilled through the glass. The most satisfactory method of setting up is to align the heliotrope between the station dot and the observer, facing the mirror directly towards the latter. An assistant takes a pole to a distance of at least 25 feet and places this in the true alignment as given to him by the operator, who looks through the hole in the mirror. The operator then directs the pole-man to place a piece of grass or string round the pole, at such a height as to be coincident with the observer's position. This mark on the pole then corresponds to the cross hairs of a heliograph sight-vane, and to show a light all the operator must do is to turn his mirror until the shadow of the dot strikes the mark.

(e) *A heliostadt* consists of a single mirror, with central hole, fitting into a frame allowing of movement on a horizontal axis. The frame fits on a spike, which can be driven into the ground, or, preferably, into a solid block of wood. The setting up is exactly similar to that with a heliotrope, but, as the whole apparatus has to be turned for horizontal adjustments, care must be taken that the alignment between station dot and observer is not lost.

(f) In order to get good work from lightmen it is essential to drill them carefully at the beginning of each field season, before commencing work, when the method of signalling by double reflection might also be taught.

It is advisable to send two men out in charge of each light, partly because the lightman, whose duty it is to show the signal nearly all day, requires assistance in cooking, etc., and partly because the second man, who is generally untrained, has thus a good opportunity of becoming practically acquainted with the work, whilst in case of sickness the presence of a second man is imperative.

Management of Lightmen.

232 The routine of lightmen is necessarily made simple, in order to be within the comprehension of the uneducated men who are employed on it, and consists of a few readily understood signals, as follows:—

(a) When the observer wishes to observe a distant station light, he, with his own heliograph, shows a steady light on that point, until the signaller has adjusted his heliograph and shows a steady light; he then turns off his light, and the signaller is required to keep his light fixed throughout the whole day. If he gets careless a steady light is again sent to him, by which he understands that he is to see carefully to the adjustment of his light, as it has probably got off the line owing to the motion of the sun.

(b) When the observations to any station are completed the lightman may be dismissed, or given his signal to move on, as follows: The observer shows two lights 20 to 40 yards apart; the lightman turns off his light for a minute, and then shows it again. If he still sees two lights from the observer's station, he turns off his light, gives a flash to show he understands, and packs up and moves on to his next station, or stays, according to his programme.

(c) When the lightman is capable of reading the Morse code one light only will be used by the observer. He flashes on the lightman to call him up, and the latter turns off his light. The observer then sends the word MOVE, to which the lightman replies with R.T., to which the observer gives a flash of acknowledgment.

(d) If it is required to cease work for the day, and a light will be required to the same point on the following day, the signal C.W (cease work) is sent by the observer, after calling up as before, and the lightman replies R.T.

(e) Before despatching the lightmen to their stations a triangulator should draw up a programme, giving each man a list of stations in consecutive order from which he is to signal. If this programme is carefully made out, and the men are thoroughly instructed as to their movements from station to station, much trouble will be avoided, and very few mistakes should occur.

(f) At short distances even a 6-inch mirror will be too bright to observe with precision, and its light must be partly reduced; this may be done by fitting on the diaphragm with which most mirrors are provided, thus limiting the exposed part of the mirror's diameter to 2 or 2½ inches, but a more convenient method is to have a piece of muslin or black crèpe stretched on a slip of bamboo, bent into the shape of a tennis bat, held in front of the object glass of the telescope of a theodolite. A cardboard cap, with muslin stretched over the aperture, will answer the same purpose.

Refraction.

233. (a) There is reason to believe that refraction takes place chiefly in the vertical plane; but owing to the smoke and various vapours perpetually rising from the earth probably not having a uniform density at a given height above the surface, the ray in its passage through these must unquestionably be, to some extent, liable to lateral as well as vertical refraction. We see, in fact, both by night and day that this cause is perpetually in operation; for the small disc of an argand lamp, which is only 12 inches in diameter, and in a clear settled atmosphere is reduced to a luminous point, swells out sometimes for several nights in succession into a broad, ill-defined blaze, subtending occasionally 2 minutes of the horizon, and vibrating more like a sheet of fire than an object intended for accurate intersections, whilst by day the visible disc of the heliotrope, though only 2 inches in diameter, is even wilder and more straggling.

(b) The only method of overcoming these sources of irregularity is to await a favourable state of the atmosphere, and be prepared to profit by it when it offers itself. Such occasions occur for day observation almost every sunny day, for a shorter or longer period, between 3.30 P.M. and sunset. The lamps are also frequently well adapted for observation from sunset to past midnight, especially in

the early part of the season, but at other times they are steadiest from after midnight till about sunrise.

(c) In hilly countries, where the stations are placed on lofty peaks with deep intermediate valleys, objects are less disturbed by atmospheric causes than under other circumstances. Very good observations may then be obtained for an hour or two after sunrise; but, in general, however promising the apparent state of the atmosphere may be at sunrise, it can rarely be depended upon. It is at this period of the day that mirage is most conspicuous. Two or three heliotropes are sometimes seen piled one above the other, or placed side by side, sometimes uniting together to form columns or pillars of fire subtending several minutes, although the rays of light pass through an aperture limited to 2 inches in diameter. This kind of internal refraction is, however, too conspicuous to be overlooked; but there is another insidious sort which ought to be carefully guarded against, because at the time it is in operation the visible disc of the lamp or heliotrope appears at first sight small, well defined, and steady; if, however, it be carefully bisected by the wire, and then watched, it will be found after the lapse of a few minutes gradually to diverge to one side, and after a shorter or longer time will again move off slowly in another direction. This treacherous state of the atmosphere is very frequently in operation, and the only remedy is to watch carefully, and adjust the position of the telescope so that the object may appear to diverge equally on each side of the wire. With this precaution good observations can be made, but each intersection occupies several minutes of time, and the observations proceed very slowly.—(S.I.)

Theodolites.

234. The instrument used for running the main triangulation is the 6-inch microscope theodolite by Messrs Troughton & Simms, which is fitted with a powerful telescope, but for the minor triangulation a good 5-inch instrument will suffice. These theodolites are very handy and portable instruments with simple adjustments, and in the hands of skilled observers are capable of giving results more than good enough for any topographical work. The average triangular error for a season's work with the microscope class of instruments should certainly not exceed 2″ to 5″, according to the precautions adopted, if luminous signals are used. A memorandum on modern theodolites by Captain Turner, R.E., is given in the Appendix, *Handbook Topographical Branch, Survey of India*, 1905, where the adjustments of these instruments are fully described. Further reference to *Close*, p. 11.

Centering of Theodolites and Signals.

235. The observer will of course take the greatest care in centering his theodolite exactly over the station mark, but he should remember that all his care will be thrown away unless he can succeed in impressing on his signallers the necessity for equal care in centering the heliograph, etc., and he will do well to make a show of extreme scrupulousness on this point whenever setting up his instrument, even where accuracy is not imperative, in order to cultivate this habit among his natives.

236. It is indispensable for good observing that proper shelter from wind, sun, or rain should be provided for the theodolite, and this is furnished by cockshys. Lightmen visiting any station are responsible that the thatching of these is in good repair.

Observation Requirements and Procedure.

When possible the observer should be given the services of a recorder, as this will add greatly to the speed and comfort of the work, and, to some extent also, to its accuracy, for the recorder's business is to take out the means of the vernier readings and angles whilst the work proceeds, and to call the observer's attention to any discrepancies.

On completing all rounds to stations the observer should at once scrutinise the results, and when large differences appear the doubtful measures should be repeated before doing other work. If this important precaution is omitted errors will often subsequently be found when there is no means of rectifying them.

After a short experience in the field the observer will know what to expect in the matter of agreement between measures on each zero, and must then lay down a criterion for his own guidance. Instruments and conditions vary so much that no hard-and-fast rule is possible, but when using a modern 6-inch micrometer theodolite all measures of the same angle should fall within 10″ or 15″, provided the signals are clearly visible.

Measures which do not comply with the adopted criterion must be repeated at once.

237. Before commencing work with the theodolite the observer should orientate the plane table on which his reconnaissance chart is mounted in a convenient position, and read out (or enter in his book if he has no recorder) the names of the stations to which he has decided to observe rays, proceeding from his selected zero station, in the direction of the hands of a watch, and closing with the zero station. The best point to select for the zero station is that which is most likely to be clearly visible all day. He will usually have to observe both main and minor rays, and as the former are observed on more zeros than the latter, he may either observe them in two groups, or may omit the minor rays in the last two rounds.

Use of Reconnaissance Chart when Observing.

The former is the best plan, and should be adopted except when either class of ray is limited to a very small number, or when time is of great importance. After completing observations to all stations, reference is again made to the plane table, and commencing with the same zero station, if visible, the names or numbers of all the intersected points are written down in the order in which they will enter the field of view when revolving the telescope from left to right, the zero station again closing the list.

238. A "swing" is a continuous motion of the telescope round the circle, beginning and ending with the zero station. It may be made in either direction, *i.e.*, either clockwise (swing right), or counter-clockwise (swing left).

Definition of Terms Used in Observing.

A "measure" is the number of degrees, minutes, and seconds con-

tained in an angle. Each angle must be measured more than once, as a single measure is not free from error.

A "setting" is the division on the limb at which vernier A is clamped on beginning a round of observations.

Measurements of Horizontal Angles.

239. (a) The number of measures to be made of each angle depends chiefly on the class of work in hand, and the following table will furnish a useful guide :—

Class of Triangle.	*Number of Measures of Each Angle.*
Main	6
Minor	4
Intersected Points	2

(b) The number of zeros depends on the class of instrument used, and is based on the following consideration :—

1. Each measure should be independent and unbiassed.
2. Each measure should, if possible, be made on a different part of the arc.
3. On each zero the measure made must be balanced in respect of the direction of the "swing" and "change of face."

(c) The measurements will be made on different zeros, the following being a good guide :—

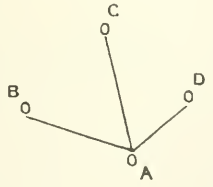
1. Zero 0° face right, swing right
2. „ 0° face left, swing left
3. „ 35° face right, swing right
4. „ 35° face left, swing left
5. „ 70° face right, swing right
6. „ 70° face left, swing left

} Do not set at exactly 0°, 35°, and 70°, but within a degree of them.

All six to be observed in main, and the first four in minor, triangulation. For intersected points, the first two.

Another zero to be taken if the angles exceed the values given in para. 250.

(d) The angles at a station are taken thus: Supposing the observer to be at A, and the signals at B, C, D are all visible, the instrument is carefully levelled and clamped at 0°, the lower plate being unclamped and the face of the vertical circle on the right. The instrument is then turned round in azimuth so that B reads



0° on vernier A ; B is then called the zero station. Suppose the telescope to be brought up from the left hand of B, and turned gently, so that B may enter the field of view and come near the centre wire, but not pass over it, the lower plate must then be clamped, and the bisection of B completed by using the slow-motion screw.

All the verniers are now read, and the recorder enters the readings in a fair legible hand in the Angle Book. The observer should then look again into the telescope to see that B remains bisected. If found correct the upper plate is to be gently unclamped and the telescope moved by means of its supports towards C, care being taken not to overshoot it. The clamping, bisecting, and reading is done as before, and similarly also for D. The "swing" is then continued, and the zero station B is again observed. A comparison of this reading with that previously obtained will test the stability of the instrument. A complete round of observations is thus obtained at "setting" zero 0°, face right, swing right, which can be rendered "0°, F.R., S.R." for short.

Now "change face" by turning the telescope through 180° in a vertical plane, so that the face of the vertical circle will now be to the left hand, clamp station B at 0°, and proceed as before, except that the motion or "swing" of the instrument is from right to left. This is called "setting" zero 0°, face left, swing left, or "0°, F.L., S.L."

(e) All three angles of each triangle should be observed for main and minor stations.

Auxiliary Station.

240. When it is found while observing that a certain portion of the ground is commanded from two stations only, it will very often be found feasible to select an auxiliary station of observation from which a third ray can be obtained to the intersected points in this area. To do this choose a convenient station from which two of the previously chosen stations of observation are visible, such that they will subtend a suitable angle at the new station. Take your round of angles to the intersected points and observe carefully the angle between the two stations. Leave a conspicuous mark at the auxiliary station, and when either or both of the original stations are visited include the auxiliary station in the round of angles. The angle taken at the auxiliary station, and that observed at one of the other two stations, will be sufficient if carefully taken to fix the new station, as it is merely required to get checking rays to the intersected points. Such an auxiliary station should be chosen judiciously, so as to observe at it while on the way to one of the main stations in order not to entail going back to one of them to fix it.

Marking Intersected Points.

241. In observing intersected points it is necessary that at least one, but preferably more than one, station should be observed with them in the same round, and it is essential to commence and finish with a station as a check on any movement of the instrument during the round. Intersected points should have a short description or sketch attached to them in the column of remarks of the Angle Book to assist in subsequent identification, and to ensure the same part of the object being observed in all cases. It is a rule not to be departed from, except for very urgent reasons, that intersected points must be fixed by three rays. When only two are used a large number of points are almost always lost owing to misidentification.

If intersected points are not poled they should be well-defined natural objects. To take several readings to an ill-defined object on the chance of one of the readings working out in the computations is a waste of time in the field, and entails useless labour in recess, for even if the point eventually works out it is sure to be of no value to a plane-tabler, who will fail to identify it.

Station Trees.

242. When a wooded hill has been cleared and a single tree left standing near a station, a reading of the horizontal circle on one face should be taken to it from the station and entered in the Angle Book under the head of "station tree," and the distance from the station to it should be measured and recorded in the column of remarks.

Magnetic Variation.

243. The magnetic variation having to be determined for entry on the map, the theodolite must be set in the magnetic meridian at each station of observation by means of the needle, and the reading recorded in conjunction with the reading of one of the surrounding stations. The angle derived from these two readings when applied to the computed azimuth of the station will give the magnetic variation.

Satellite Stations.

244. It may occasionally happen that the observer has, through inadvertence, intersected when observing, not the exact station itself, but a point quite close to it; on the other hand, it is occasionally necessary, in order to avoid intervening obstacles, to place the theodolite a short distance from the mark for some particular ray. In such cases all that the observer has to do in the field, is to enter carefully in the Angle Book the circumstances of the case, giving the distance of the "satellite station," as it is commonly called, and its direction referred to one or other of the distant stations. The computation of the correction to be introduced is then a very simple matter of plane trigonometry. (See *Close*, p. 22.)

Measurement of Vertical Angles.

245. Vertical angles to all stations should be measured with at least one "change of face." For stations the observations should be reciprocal, because the effect of refraction is not only thereby eliminated, but because they furnish the coefficient of refraction to be employed in reducing single, *i.e.*, non-reciprocal, vertical measurements.

The heights of the instrument and signal above the station platform must be recorded in the Angle Book; and in observing vertical angles to intersected points, the particular part of the object intersected should be noted, as well as its height above the ground level.

The level attached to the vertical arc must always be read and recorded when observing heights of stations and points. A note as to the nature of the graduation of this level must be given on the first page of the Vertical Angle Book, as the rules for reducing the correction vary according to the method used. The scale value of the level should also be entered with a note as to when and how it was derived. Levels being very sensitive thermometers, care must be

taken not to influence them by breathing on them, or by too near an approach of the body.

The practice of observing both horizontal and vertical angles simultaneously, by putting the intersection of the wires on the object and reading both sets of verniers, *should never be permitted when observing to stations.* Not only is the intersection liable to be less accurate, but the extra delay in observing the horizontal round, and the extra handling of the instrument which is necessary, are very liable to cause a shifting of the instrument, vitiating the horizontal angles.

In observing heights to signals placed on trees in forest-clad hills, it is advisable to observe both the top and the base of the tree when visible, for the height of the top of a tree is more useful to a plane-tabler in taking clinometer heights than the base, whilst the ground level is required for insertion on the fair maps and needed by the plane-tabler to regulate his contours. The foot of a tree being frequently invisible from some stations, the height of the tree above ground level should be determined by a native by means of a string and plummet, or subsequently by the plane-tabler employed on the detail survey.

Vertical angles to intersected points should always be observed on both faces. It is a slovenly and bad method to merely take them on one face, and note the index error of the verticle circle. (See *Close*, p. 21.)

246. It is most essential, in order to avoid errors and loss of time, that the angle books in which the measurements made by the theodolite are recorded should be systematically and clearly kept up. All entries must be made in ink on the spot, and no erasures are permitted. The following abbreviations are recommended for adoption in the angle books' computations :—

Horizontal Angle Books.

△ A. for hill station of the main triangulation.
▽71. „ „ minor triangulation.
pp. „ pole.
p.f. „ pole and flag.
t.p. „ pole on tree.
v.t.p. „ „ near village.
h.t.p. „ hill tree pole.
t.f. „ flag on tree.
hel. „ heliotrope or heliograph.
f.s. „ flag staff.

Duplicate angle books are not required.

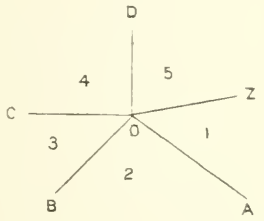
The name of the station of observation should be entered in Roman letter or full round hand. Names of stations to which rays are to be observed should be similarly written in full for the first round, and given distinguishing numbers or letters. The second round is written in reverse order, using the numbers only, and, for the sake of brevity, these numbers may be used for all subsequent rounds recorded. A clear space of one or two lines should be left between each round of angles ; also a blank page left for the abstract, before commencing to write out the intersected points.

The stations of observation must be very carefully described, so that anyone subsequently wishing to make use of them may have no difficulty in finding and identifying the marks. The directions and distances of the neighbouring villages should be given, and the local name of the spot, if any exists, also the best means of getting to the station, and the name of the village in whose lands it is situated, together with the name of the district, the distance and bearing of the mark tree, and any other information likely to prove useful in the future.

Taking Out the "Means" and "Abstract" of Horizontal Angles.

247. On returning to camp the recorder will go through his work again, and at the earliest opportunity the observer will re-check all means and angles, and prepare an abstract which will subsequently be checked and signed by the recorder. There are various methods of making out the abstract, but the following seems the best, and should be generally adopted by topographical parties.

In the figure, O is the station of observation, and Z the zero station. Each round gives one measure of each of the angles ZOA,



AOB, BOC, COD, and DOZ, *i.e.*, of five angles which in the following example are given imaginary values.

The first step is to find the mean values of each angle as follows:—

MEANS OF ANGLES.

Zero.	*1*	*2*	*3*	*4*	*5*
	30° 3′	89° 21′	65° 47′	35° 36′	89° 10′
L 0 . .	15″	55″	7″	59″	27″
R 180 . .	18	43	13	67	35
L 45 . .	13	51	10	64	40
R 225 . .	30	67	19	73	39
L 90 . .	25	56	15	80	21
R 270 . .	17	59	27	69	28
L 135 . .	23	50	21	65	38
R 315 . .	19	49	17	60	30
Sums .	160″	430″	129″	537″	258″
Means .	20	53·5	16·72	67·13	32·25

Then follows an abstract :—

ABSTRACT OF ANGLES.

Name of Station.	*Angle.*	*Correction.*	*Corrected Angles.*	*Abstract.*
	° ′ ″	″	° ′ ″	° ′ ″
Z . .	—	—	0 0 0	0 0 0
A . .	30 3 20·00	−0·75	30 3 19·25	30 3 19·2
B . .	89 21 53·50	−2·24	89 21 51·3	119 25 10·5
C . .	65 47 16·12	−1·63	65 47 14·15	185 12 25·0
D . .	85 37 07·12	−2·14	85 37 05·0	270 49 30·0
Z . .	89 10 32·25	−2·24	89 10 30·0	360 00 00·0
Sum .	360 00 09·00	−9·0	360 00 00·0	—

This form should be used for "minor" rays also, and it may be noted that two places of decimals of seconds are entered in the tables of means, and one place in the corrected angles column in the abstracts. The correction applied in the abstract, to make the sum of all the angles equal 360°, is made proportional to the size of the angle. When both minor and main rays are observed, two separate abstracts will have to be made, the same zero station being used in both. The abstract of the intersected points should be made on the right-hand side of the page on which the angles are recorded, and in doing this, it will suffice to take the mean of the first and last readings of the zero station, and correct all the angles by applying to each the difference between the mean value and 0°.

Completion of Angle Books.

248. It is most desirable that the abstract of horizontal and vertical angles, and all other details of the angle books, including paging and indexing, should be written up, examined, and signed during the field season as the work progresses; but, if for any reason this has not been possible, it should be taken in hand the first thing on return to Headquarters before any of the computations are begun. Most scrupulous attention must be paid to neatness and methodical arrangement of all records and computations. Good handwriting and freedom from blots, erasures, and interlineations are essential.

Computation.

249. (a) The whole question of the computation of triangles is dealt with in *Close* (p. 23). The forms used are Southern Nigeria Survey Nos. 33 to 37, and 44 to 47.

(b) The "intersected points" are computed on Southern Nigeria Survey Form No. 44. In these the third angle is always unobserved, and its value is supplementary, *i.e.*, it is obtained by taking the sum of the first two angles from 180°. The majority of these points should be fixed by observations from at least three stations, otherwise there is no reliable check on their identification. If, however, the height of an intersected point is

observed from two stations the accordance of the two results furnishes a test, though not a very rigorous one, that the same point is observed from both; the test is the more reliable the steeper the rays to the point observed. If a point P be observed from three stations A, B, C, two triangles A B P and B C P may be computed, giving a double value of the side B P, the agreement of which will furnish a test of the accuracy of the work. In such cases it is useless to compute (as has sometimes been done) the triangle A C P, no new information being obtained thereby. The lengths of sides in feet should be computed to units and in miles to thousands. Five places of logarithms are sufficient for the computation of intersected points.

The computations of points found wrong by the plane-tablers should be examined, and if the error be due to want of identification by the triangulator they should be expunged from the angle books' computations and triangle chart.

Limits of Errors of Triangulation.

250. Average linear errors of the main triangulation should not exceed 1 : 15,000, and triangular errors 6″. In minor triangles these errors should not exceed 1 : 10,000 and 15″ respectively if luminous signals are used. For intersected points the linear error will largely depend on the kind of object intersected—if it be a pole or tree stem, or temple or other well-defined object, the error should average perhaps about 1 : 5000.

Method of Deducing Linear Errors of Triangulation.

251. In deducing the linear errors of the triangulation the mean of all the values of the same side is to be taken as the correct value, and the differences between that mean and each separate value will be the linear errors in each case, which are to be used in calculating the general mean linear error for class of triangles. There is a still more direct method of deducing the same thing from the log sides only, which, though not rigorously correct in theory, is probably more accurate in practice owing to the feet being given only to the nearest tenth. The method is as follows: Take the mean of the logarithms to represent the correct logarithm of the side, subtract each logarithm from this mean, take the mean of the differences, and, treating it as a whole number, divide by 68[1]; the result is the linear error in inches per mile. Thus suppose the three logarithmic values of a side to be 4·8149322, and 4·8147443, and 4·8147559; the mean is 4·8148108. The differences between this and each of the logarithms are ·0001214, ·0000665, and ·0000549, the mean of the three being ·0000809; then the average linear error in inches per mile will be $\frac{809}{68} = 11{\cdot}9$.

Computation of Latitudes, Longitudes, and Azimuths.

252. The computation of latitudes, longitudes, and reverse azimuths should be next undertaken. The form used is Southern Nigeria Survey No. 46.

[1] More exactly this is 68·54.

253. The latitudes, longitudes, azimuths, and sides contained in the foregoing computations must now be entered in the synopsis Table IV., Southern Nigeria Survey Form No. 36. Care should be taken that every side which has been computed be entered, and that no side should appear twice; that where mean values are obtainable they should be entered, and that the numbers of the triangles from which the values have been obtained be recorded in the appropriate column. This compilation will then be a complete synopsis of bases, the values of which will correspond with those given on the charts of triangulation to be described hereafter. The synopsis should be filled up step by step, and not left till the latitudes and longitudes are completed. As the triangles are computed the computers should enter the values obtained. This prevents any chance of a side being entered twice, and ensures the mean value being adopted when required as a base for computing fresh triangles. Much time is wasted in looking back through the triangle sheets for a base if the synopsis is not kept up *pari passu* with the computations.

Synopsis of Latitudes, Longitudes, Azimuths, and Sides.

254. The computation of heights of stations is fully explained with numerical examples in *School of Military Engineering Notes* and *Close*. The form used is Southern Nigeria Survey No. 45. The heights should be retained to tenths of feet. Refraction can only be computed in the cases where there are reciprocal observations between the stations. The co-efficient of refraction should not be obtained from sides less than 10 miles, as errors in the heights of the instrument and signal have too great a proportional effect when the distances are shorter (see *Close*, p. 28).

If no refraction be forthcoming it is usual to take it as $\frac{1}{15}$, or 0·07 of the contained arc.

Computation of Heights.

255. (a) As the first essential in arranging the records of a survey is to have a means of supplying data of points fixed by the survey to those requiring them, the results of the triangulation or traversing of topographical parties are published in the form of a chart, bearing on it a printed list of the co-ordinate values of all stations and points included in it.

(b) The triangulation chart will be published on two scales, viz:—

1:250,000, showing areas comprised by 1° latitude and longitude.

1:500,000, showing the whole country.

Triangulation and Traverse Charts.

Original Chart.

(c) To enable the Headquarter Office to compile and publish the above-mentioned charts, the Assistant Director, Trigonometrical Section, will furnish annually at the end of the field season triangulation charts on a scale of 1:125,000 showing half-degree areas.

These charts will be given the same names as the standard sheets which they respectively cover.

The letters used in the triangulation to denote the stations of observation must be printed or typed on this chart—capital letters

for major, and small letters for minor, stations. Intersected points will be numbered with the same numbers as were used in the triangulation. All traverse stations of which the latitudes and longitudes are known will be included in the chart and given Roman numerals.

The nearest village to each point will be shown. All trigonometrical and traverse stations and points must be shown by the symbols given on the Conventional Sign Sheet—the rays between principal stations in broad heavy lines, minor triangles in medium lines, and auxiliary triangles in fine lines; partially dotted rays to be be drawn to intersected points.

Traverse lines connecting the permanently marked traverse stations should be dotted as thin as possible and the number of the traverse printed along with them.

With the original chart must be submitted a list of data in manuscript. This will comprise a list of stations with their co-ordinates, rectangular or spherical, and heights, followed by a list of the intersected points and permanently marked traverse stations, the reference numbers on the chart being arranged serially, followed by the names of the intersected or traverse points with their co-ordinates and heights.

Each original chart must include, not only the triangulation and traversing done by a party, but all previous triangulation and traversing falling in the area of the chart. In order to ensure that nothing is omitted the Assistant Director, Trigonometrical Section, should obtain from the Headquarter Office all data and information on the subject. Rough reconnaissance triangulation, which precedes or accompanies geographical surveys, and triangulation which is classed "confidential," are not to be entered on the chart.

Where the triangulation of more than one party is entered on a chart an extra column should be added to the tabular statement following the column of heights, headed "series of triangulation," with reference letters indicating the series of triangulation from which the data are taken, and an explanatory note at foot. This information is required to enable the original data to be referred to at any time.

(d) The published charts will also be prepared on the principles mentioned in (c), but the trigonometrical stations will be numbered serially throughout the colony in heavy black type, and the intersected points and traverse stations in small fine type.

The published charts will have printed on them two tables showing :—

I. The new numbers, old numbers used in the triangulation, name (if any), co-ordinates, and heights, arranged in six columns, with a seventh column for remarks of all trigonometrical stations.

II. Ditto for intersected points and traverse stations.

(e) The published chart will be brought up to date annually by the publishers.

256. The annual report of a trigonometrical party should be prepared on the following lines :—

Annual Report.

I. Title-page — showing the province of survey, the degrees of latitude and longitude, and the season.

II. A copy of the Index Map, scale 1:1,000,000, showing area

dealt with during the season, in the following colours, no points being shown :—

Red Wash . .	Main and minor triangulation completed.
Blue Wash . .	Main triangulation completed, no minor required.
Green Wash . .	Main triangulation completed ; minor beaconed, partially observed.
Yellow Wash . .	Main triangulation completed ; minor to beacon and observe next season.

III. Charts of triangulation at 1:125,000, showing all points and the triangles by which they have been fixed. To this will be attached Tables. Full description given in para. 255.

IV. A narrative of the season's work and remarks on organisation, etc.

V. A brief account of the country surveyed, of the data of the survey, and any other matter of technical interest.

VI. A Table showing the number of points fixed under each division of the triangulation—main, minor, auxiliary, and intersected, —giving triangular and linear errors and area covered.

VII. Full notes on all stations and points with special reference to natural and permanent marks, cockshies, etc. ; also notes on camping places, roads, etc.

The following will also be handed in as Appendices :—

1. Trigonometrical computations complete, divided into three sections—namely, (1) main, (2) minor, (3) intersected and auxiliary points.
2. Trigonometrical angle and abstract-books.
3. Compilations of star observations.
4. Astronomical angle books.
5. Diary.

In compiling his report the Assistant Director, Trigonometrical Section, must remember that paras. V. and VII. should be written in such a form as will give future survey parties the greatest information.

CHAPTER VIII.

BASE MEASUREMENT.

Part I.—Apparatus.

General Description.

260. TOPOGRAPHICAL base lines for the Southern Nigeria Survey triangulation are measured with invar wires in conjunction with the apparatus designed at the Bureau des Poids et Mésures, Paris. The principle of the method is the absolute determination of the horizontal intervals between a series of tripods, which are so constructed as to form, during the time of measurement, "fixed points," and the measure is supplied by a wire, of which the exact length at standard temperature (when hanging freely in catenary) under a constant load has been determined.

Properties of Invar.

261. Invar is the name given to an alloy of steel, whose co-efficient of expansion for temperature is one-tenth that of any other known material suitable for tapes or wires. The mean co-efficient of the six wires used on the Eruwa base was ·000,000,600, whereas for steel wires this would be ·000,008,900.

Description of Apparatus.

262. I. *Wires.*—The wires are of 0·7 mm. diameter, and fitted at each end with a triangular reglette, of which one face is in prolongation of the axis of the wire. On these reglettes are graduations in millimetres from 0 to 80, the two scales reading in the same direction along the wire. When the wire is hanging freely in catenary under a strain of 20 kilogrammes, the distance between any pair of similar graduations is 24 metres (plus or minus the slight standardisation correction to be dealt with below). Thus the distance between any two graduations on the scale is 24 metres + (fore reading − back reading), or 24 m + (F − B) mm.

The wires when not in use are carried on steel drums of 50 cm. diameter, fitting into wooden boxes supplied with bearings for rolling up and unrolling.

II. *Straining Trestles.* — The reglettes referred to above are furnished with swivel staples, to which are attached swivel hooks when the wires are in use. To the other extremity of each hook is attached the straining cord which passes across the *straining trestle* and supports a weight of 20 kilogrammes. The straining trestles are three-legged, the centre leg being longer than the others, and

fitted with bearings for the straining pulley, and with an upward prolongation to act as a lever for adjustments of position. The pulley is carefully "trued," and fitted with ball bearings to reduce the friction to a minimum and thus preserve a constant strain on the wire.

III. *Tripods.*—The "fixed points" between which measurement is made are supplied by firmly constructed wooden tripods, shod with iron and fitted with gun-metal heads, furnishing opportunity for slight adjustments of line or interval. These heads carry a pillar on which is a knife edge and cross mark, and against these the graduations on the wire reglettes are read off during measurement.

IV. *Supplementary Apparatus.*—Additional apparatus consists of a telescope for alignment of tripods, a level for ascertaining slopes between tripods, *see* para 266, VI., magnifying glasses for reading graduations, swivel hooks, spiral springs, and an 8-metre tape for measurement of short lengths.

263. *Wires.*—The greatest care must at all times be taken of the wires, which are somewhat delicate in construction, and are liable to alterations in length through shock or strain.

Use of Apparatus.

During unrolling the drum is firmly held by one operator, who regulates the speed, and is in charge of the work; another operator attaches a swivel hook to the staple at that end of the wire fastened to the spring terminal of the drum, and walks steadily backward from the drum, drawing off the wire gently. When completely unrolled a swivel hook is attached to the inner end, both hooks are then attached to spiral springs on two poles, which form the vehicle for conveyance of wire from bay to bay during measurement. During rolling up the converse operation is gone through, the drum operator winding the wire in. It is essential that the wire be always wound in the same place on the drum and in the same direction.

Trestles.—The trestles are firmly set up with the long leg in the line of measurement, and the upper surface of the pulley in the same vertical and horizontal planes as the centres of the knife edges.

Tripods.—The tripods are aligned and firmly set up with the leg under the telescope pillar to the right of the line, the other two to the left. The heads are levelled with the foot-screws, and the knife edges turned at right angles to the line.

Part II.—Measurement.

264. The terminals of the base to be measured having been selected, a theodolite is set up at one or both, and a line cleared between the two points to a width of 10′ or 12′. This width can be reduced at sections where the bush is very heavy, but anything less than 10′ retards progress considerably and increases the risk of tripods being shaken. The clearing should go right down to the ground, and all overhanging trees that obstruct the theodolite ray must be cut away. Concrete beacons are let in at convenient positions along the line to act as theodolite stations in the pegging out. The clearing being completed, the centre is carefully pegged out at intervals of 24 metres (78·74′)

Clearing and Marking Line.

with the theodolite and a special gauge wire, these pegs giving the positions of the tripods during measurement. It can then be determined how obstacles, such as streams and rock outcrops, are to be dealt with, and, if necessary, tripod platforms can be erected in advance. A rough estimate of the length being thus arrived at, the distance is divided into sections of such length that two shall form a day's work. It must be borne in mind that all obstacles detract considerably from the rate of work, and the sections containing these shortened accordingly.

It may, however, be found that time for this pegging out is not available, and in such a case conspicuous vertical posts are erected along the centre line at such intervals and positions that two at least are visible from any point, and on no account should they be more than half a mile apart. The aligner then sets up his tripods with use of a tape or gauge wire and the aligning telescope. This method is good if an experienced surveyor is available for the subsequent aligning of tripods, but otherwise is productive of endless trouble.

265. The base terminals are stout iron pins firmly bedded in a pillar of concrete and raised about 3 feet above the ground-level. The heads are domed with a flat surface of 1-inch diameter, on which cross hairs are engraved.

Terminals.

The section terminals for ordinary soil are iron pegs 15 inches in length, cup headed, and are driven until firmly held, and projecting from 3 to 6 inches above the ground.

If it is imperative to place a section terminal in rock, a hole must be bored and a short, nicked pin set in cement. Extending or shortening the section by one or two bays should however almost always obviate the necessity of terminals on rock.

266. I. The following procedure, modelled on that described in the excellent article contributed to the *R.E. Journal* for September 1909 by Captain E. M. Jack, R.E., was found satisfactory during the measurement of the Eruwa Base, December 1910.

Procedure in Detail.

The party was organised as follows :—

Recorder	1 Surveyor.
Fore and Back Readers (F.R. and B.R.)	2 Surveyors.
Leveller	1 Surveyor.
Aligner	1 Surveyor if the second method is used ; otherwise, a Headman.
Trestle Men	2 Assistant Surveyors.
Wire Carriers	4 Carriers.
Tripod Men	10 Carriers.
Trestle Assistants	4 Carriers.
Leveller's Assistants	3 Carriers.
Spare Men for umbrellas, wire boxes, tape, etc.	10 Carriers.

II. The tripods and straining trestles being in position, the wire carriers bring their poles near the tripods, and the readers unhook simultaneously, the fore reader giving the signal with a nod for this and all similar movements. The weights are held up by the trestle assistants, and the trestle men hand the "S" hooks on the straining cords to the readers, who make connection with the swivels previously attached to the wires (*see* para. 263). When all is ready the weights are slowly lowered on the words "*Weights down*" from the fore reader. Any slight adjustments of trestles are then made, so that the reglette graduations at either end fall across the knife edge. The fore reader calls "*Are you ready? Up.*" On the word "*Up*," each reader notes with a magnifying glass the graduation at that instant vertically above his knife edge. This is then called out to the recorder by fore reader and back reader in turn as a whole number in tenths of millimetres. Thus a reading of 20·3 millimetres (the decimal being estimated) is recorded as 203. Two readings are taken, the back reader giving the word "*Up*" for the second one, and the recorder books these and calls "*Right*" if their differences fall within the permissible limit (*see* para. 268). On this word the trestle men steady the wire while the readers change to the opposite side, passing round behind the tripods and not under the wire or cord. Two more readings are then taken as before, and if these prove satisfactory "*Right*" is called by the recorder, the fore reader gives word "*Weights up*" for the weights, and the wire is unhooked from the straining cords and hung up on the carrier poles. The whole procedure is then repeated with the wire. This completes the measurement of one bay.

If any measures do not fall within the limit referred to above, they are immediately retaken. The bay being satisfactorily completed, the wires are moved on to the next pair of tripods. The aligner is responsible that there are always sufficient tripods ready for the measuring party, and also that two complete bays are left in rear of that under measurement.

III. The greatest care must be taken that the tripods are not moved and shaken, and if this should occur, the bays concerned must immediately be remeasured, the first measure being discarded.

IV. The recorder books up the readings on Southern Nigeria Survey Form No. 50, makes the subtractions (FR − BR), enters the mean of the four results, and keeps the column of summations up to date. He enters up the temperatures as given by thermometers, one on each carrying pole and one swinging near the centre of the wire. It is sufficient if these three are each read once at equal intervals throughout the measurement of a bay, and the correction for their mean temperature applied.

V. On the first and last bays of sections the measurement is made direct from the section peg to the tripod, a straining trestle being employed behind the tripod, the other end of the wire being attached (by a spiral spring to prevent jar) to a pole or pin fixed in the ground beyond the peg and held by the trestle man.

VI. *Levelling.*—The levelling telescope supplied with the Guillaume apparatus is not sufficiently accurate, and a Dumpy level with a staff graduated to read to feet and hundredths is used. The leveller records on Southern Nigeria Survey Form No. 51 the difference of

height between each pair of tripods, the staff being placed on the wooden portion of the tripod head and on the top of the section pegs. On the first and last bays of sections he measures the height of the tripod pillar above this wooden framework, and adds this to his upper staff reading to obtain the exact difference. He works out the reduced height at section terminals, for use in calculating the correction for reduction to mean sea-level (*see* para. 272).

The tripod immediately in rear of the bay under measurement must not be approached by the staff man.

VII. The base is measured twice, the reverse way the second time, and the mean taken.

Part III.—Calculations.

Standardisation.

267. In addition to the two or three wires used for field measurements, three wires whose length has recently been determined at some physical laboratory are kept for standardisation purposes. Before commencing the measure of the line a test base of five bays is laid out, for which suitable terminals are steel rails set vertically in a pillar of concrete with a small flat surface and engraved cross hairs on top. This base is then very carefully measured twice with each standard and field wire, the mean given by the standard wires is taken as the true length, and the *standardisation correction* to be applied to the field wires determined from this. If at any subsequent time during measurement it is found that the field wires are giving varying results, a comparison with the standard wires can be made over any bay, and the standardisation corrected accordingly. On the completion of the two measurements of the base the test base will again be measured, and the standardisation corrections for intermediate days interpolated. The wires alter with use, and a gradual increase or decrease of this correction will be noticed.

Range of Bay Measures.

268. The permissible range of measurement with one bay for four readings is 0·4 mm., and when this is exceeded more readings will be taken until the ratio $\frac{\text{Range}}{\text{No. of readings}} = 0{\cdot}1$.

For standardisation and comparison this ratio must not exceed 0·05 mm.

Range of Section Measures.

269. The difference between forward and return measures of any section must not exceed $4\sqrt{\kappa}$, where κ is the length in kilometres of the section, giving a P.E. of $\frac{1}{500{,}000}$ on a section of 1 kilometre.

Length of Section.

270. On the conclusion of a day's measurement the recorder's and leveller's figures must be independently checked, and the corrections for difference of level entered and summed up for each section.

The true length of the section can now be obtained in the following form, all figures being given in millimetres.

Section XI., 37 bays.

Differences from exact number of bays.

	Wire 120.	*Wire* 121.
Summation (±)	+166·567	+209·435
Temp. Correction (±)	+008·618	+005·062
	+175·185	+214·497
Standardisation (±)	−059·940	−099·160
1·62 mm. for 120 2·68 mm. for 121	+115·245	+115·337

Mean of two wires +115·291
Level Corrections −378·765

Total Correction −263·474 mm.

Length of section for this measure—
37 × 24 m. − 263·474 mm.

271. *Further Corrections.*—In geodetic work further corrections are made for deformation of catenary due to slope, and for alterations to the Table due to the slight excess or deficit on 24 metres. In topographical work these are negligible.

Section.	*No. of Bay.*	*First Measure. Forward.*	*Differences in mm. from Exact Multiples of 24 m.*					
			Second Measure. Return.	*Third Measure. Forward or Return.*	*Diff. 1st & 2nd.*	*Diff. 1st & Mean 2nd & 3rd.*	*Diff. 2nd & Mean of 1st & 3rd.*	*Permissible Diff.*
I.	39	−122·977	−125·684	—	+2·707	—	—	3·87
II.	36	−397·564	−397·005	—	+0·559	—	—	3·49
X.	32	+6245·858	+6244·005	—	+1·863	—	—	3·60
XVII.	—	−972·817	−988·357	F. −1000·233	−15·540*	—	−1·837	—
Sum	609	+16747·962	—	—	—	—	—	—
		−9194·229	—	—	—	—	—	—
		+7553·733	—	—	—	—	—	—

* This difference being more than $4\sqrt{\kappa}$, a third measure is taken, and the mean of the two forward measures adopted, as of equal weight with the one return measure.

Summation of forward measure, taking means where necessary	=	+7553·733 mm.
Summation of return measure . .	=	+7545·347 mm.
Mean of forward and return measures	=	+7548·386 mm.

Length of base *in situ* = 24 × 609 m. + 7548·386 mm.

272. This value must be reduced to that at mean sea-level (see *Close*, p. 7). The correction applied is $\frac{h}{R}$ l, where h is mean height of the base line above mean sea-level, R is the radius of the earth (20,900,000 feet), and l is the length of base on ground-level. This correction is subtractive.

Reduction to Sea-level.

The mean height above mean sea-level is the mean of the reduced heights (*see* para. 266, VI.) of each section terminal and of the two base terminals. These heights have each been determined twice, and the mean of the two determinations is adopted as the reduced height.

And we get finally—

Length *in situ*	=	14623·549540	m.
	=	47978·39199	feet
Correction for height above mean sea-level of 346 feet	=	0·79428	feet
True length of base at mean sea-level	=	47977·59771	feet

APPENDICES

APPENDIX I.

TABLE I.—*Slope Corrections.*

(HYPOTENUSAL LENGTH = 10.)

Angle of Slope.	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′
°												
1 . .	·0015	·0018	·0021	·0024	·0027	·0031	·0034	·0038	·0042	·0047	·0051	·0056
2 . .	·0061	·0066	·0072	·0077	·0083	·0089	·0095	·0102	·0108	·0115	·0122	·0130
3 . .	·0137	·0145	·0153	·0161	·0169	·0178	·0187	·0195	·0205	·0214	·0224	·0234
4 . .	·0244	·0254	·0264	·0275	·0286	·0297	·0308	·0320	·0332	·0343	·0356	·0368
5 . .	·0381	·0393	·0406	·0420	·0433	·0447	·0460	·0474	·0489	·0503	·0518	·0533
6 . .	·0548	·0563	·0579	·0594	·0610	·0627	·0643	·0659	·0676	·0693	·0710	·0728
7 . .	·0745	·0763	·0781	·0800	·0818	·0837	·0856	·0875	·0894	·0913	·0933	·0953
8 . .	·0973	·0994	·1014	·1035	·1056	·1077	·1098	·1120	·1142	·1164	·1186	·1209
9 . .	·1231	·1254	·1277	·1300	·1324	·1348	·1371	·1396	·1420	·1444	·1469	·1494
10 . .	·1519	·1545	·1570	·1596	·1622	·1648	·1680	·1700	·1728	·1755	·1782	·1810
11 . .	·1837	·1865	·1893	·1921	·1950	·1979	·2008	·2027	·2066	·2095	·2125	·2155
12 . .	·2185	·2216	·2246	·2277	·2308	·2339	·2370	·2402	·2434	·2466	·2498	·2530
13 . .	·2563	·2596	·2629	·2662	·2696	·2729	·2763	·2797	·2831	·2866	·2900	·2935
14 . .	·2970	·3006	·3041	·3077	·3113	·3149	·3185	·3222	·3258	·3295	·3333	·3370
15 . .	·3407	·3445	·3483	·3521	·3560	·3598	·3637	·3676	·3715	·3754	·3791	·3834
16 . .	·3874	·3914	·3954	·3995	·4036	·4077	·4118	·4159	·4201	·4243	·4285	·4327
17 . .	·4370	·4411	·4455	·4498	·4541	·4585	·4629	·4672	·4716	·4760	·4805	·4850
18 . .	·4894	·4939	·4985	·5030	·5076	·5122	·5168	·5214	·5260	·5307	·5354	·5401
19 . .	·5448	·5496	·5543	·5591	·5639	·5687	·5736	·5784	·5833	·5882	·5932	·5981
20 . .	·6031	·6081	·6131	·6181	·6231	·6282	·6333	·6384	·6435	·6486	·6538	·6590
21 . .	·6642	·6694	·6747	·6800	·6852	·6905	·6958	·7012	·7065	·7119	·7173	·7227
22 . .	·7282	·7336	·7391	·7446	·7501	·7556	·7612	·7668	·7724	·7780	·7836	·7893
23 . .	·7950	·8006	·8061	·8121	·8178	·8236	·8294	·8352	·8410	·8469	·8528	·8586
24 . .	·8645	·8705	·8764	·8824	·8884	·8944	·9000	·9064	·9125	·9186	·9247	·9308
25 . .	·9369	·9431	·9493	·9554	·9617	·9679	·9741	·9804	·9867	·9930	·9993	1·0064
26 . .	1·0012	1·0078	1·0025	1·0031	1·0038	1·0044	1·0051	1·0057	1·0064	1·0070	1·0077	1·0083
27 . .	1·0090	1·0096	1·0103	1·0110	1·0117	1·0124	1·0130	1·0137	1·0143	1·0150	1·0157	1·0164
28 . .	1·0171	1·0177	1·0184	1·0191	1·0198	1·0205	1·0212	1·0219	1·0226	1·0233	1·0240	1·0247
29 . .	1·0254	1·0261	1·0268	1·0275	1·0282	1·0289	1·0296	1·0304	1·0311	1·0318	1·0325	1·0333
30 . .	1·0340	1·0347	1·0354	1·0362	1·0369	1·0376	1·0384	1·0391	1·0399	1·0406	1·0413	1·0421

Corrections for Intermediate Angles.

REQUIRED THE CORRECTION FOR 25° 53′.

TO FIND THE CORRECTION FOR ANY INTERMEDIATE ANGLE:—

Tabular Correction for 25° 55′ 1·0060
" " 25° 50′ = 0·9993
" Angular interval = 5′) 0·0067
0·0013

DIFF. from Tab. Angle 25° 50′ = 3′
0·0039
Tabular Correction for 25° 50′ = 0·9993
CORRECTION FOR 25° 53′ = 1·0032 approximately.

RULE.—Correction = Measured Length (Tabular Correction × $\frac{1}{10}$ Measured Length.)

Example. Measured Length = 537.

Angle of Slope = 13° 30′

Tabular Correction = 0·2763 × 53·7 = 14·84.

Hor.l Dist. = 537 − 14·82 = 522·16.

S.N.S. Form No. 20.

Appendix I.—Table II. *Table for Converting Feet into Chains, Links, and Decimals of Links.*

0 Chs.	1 Chs.	2 Chs.	3 Chs.	4 Chs.	5 Chs.	6 Chs.	7 Chs.	8 Chs.	9 Chs.	Links and Dec. of Links
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
0	66	132	198	264	330	396	462	528	594	00·0
1	67	133	199	265	331	397	463	529	595	01·5
2	68	134	200	266	332	398	464	530	596	03·0
3	69	135	201	267	333	399	465	531	597	04·5
4	70	136	202	268	334	400	466	532	598	06·0
5	71	137	203	269	335	401	467	533	599	07·6
6	72	138	204	270	336	402	468	534	600	09·1
7	73	139	205	271	337	403	469	535	601	10·6
8	74	140	206	272	338	404	470	536	602	12·1
9	75	141	207	273	339	405	471	537	603	13·6
10	76	142	208	274	340	406	472	538	604	15·1
11	77	143	209	275	341	407	473	539	605	16·7
12	78	144	210	276	342	408	474	540	606	18·2
13	79	145	211	277	343	409	475	541	607	19·7
14	80	146	212	278	344	410	476	542	608	21·2
15	81	147	213	279	345	411	477	543	609	22·7
16	82	148	214	280	346	412	478	544	610	24·2
17	83	149	215	281	347	413	479	545	611	25·8
18	84	150	216	282	348	414	480	546	612	27·3
19	85	151	217	283	349	415	481	547	613	28·8
20	86	152	218	284	350	416	482	548	614	30·3
21	87	153	219	285	351	417	483	549	615	31·8
22	88	154	220	286	352	418	484	550	616	33·3
23	89	155	221	287	353	419	485	551	617	34·8
24	90	156	222	288	354	420	486	552	618	36·4
25	91	157	223	289	355	421	487	553	619	37·9
26	92	158	224	290	356	422	488	554	620	39·4
27	93	159	225	291	357	423	489	555	621	40·9
28	94	160	226	292	358	424	490	556	622	42·4
29	95	161	227	293	359	425	491	557	623	43·9
30	96	162	228	294	360	426	492	558	624	45·4
31	97	163	229	295	361	427	493	559	625	47·0
32	98	164	230	296	362	428	494	560	626	48·5
33	99	165	231	297	363	429	495	561	627	50·0
34	100	166	232	298	364	430	496	562	628	51·5
35	101	167	233	299	365	431	497	563	629	53·0
36	102	168	234	300	366	432	498	564	630	54·5
37	103	169	235	301	367	433	499	565	631	56·1
38	104	170	236	302	368	434	500	566	632	57·6
39	105	171	237	303	369	435	501	567	633	59·1
40	106	172	238	304	370	436	502	568	634	60·6
41	107	173	239	305	371	437	503	569	635	62·1
42	108	174	240	306	372	438	504	570	636	63·6
43	109	175	241	307	373	439	505	571	637	65·2
44	110	176	242	308	374	440	506	572	638	66·7
45	111	177	243	309	375	441	507	573	639	68·2
46	112	178	244	310	376	442	508	574	640	69·7
47	113	179	245	311	377	443	509	575	641	71·2
48	114	180	246	312	378	444	510	576	642	72·7
49	115	181	247	313	379	445	511	577	643	74·2
50	116	182	248	314	380	446	512	578	644	75·8
51	117	183	249	315	381	447	513	579	645	77·3
52	118	184	250	316	382	448	514	580	646	78·8
53	119	185	251	317	383	449	515	581	647	80.3
54	120	186	252	318	384	450	516	582	648	81·8
55	121	187	253	319	385	451	517	583	649	83·3
56	122	188	254	320	386	452	518	584	650	84·8
57	123	189	255	321	387	453	519	585	651	86·4
58	124	190	256	322	388	454	520	586	652	87·9
59	125	191	257	323	389	455	521	587	653	89·4
60	126	192	258	324	390	456	522	588	654	90·9
61	127	193	259	325	391	457	523	589	655	92·4
62	128	194	260	326	392	458	524	590	656	93·9
63	129	195	261	327	393	459	525	591	657	95·4
64	130	196	262	328	394	460	526	592	658	97·0
65	131	197	263	329	395	461	527	593	659	98·5
66	132	198	264	330	396	462	528	594	660	100·0

CONVERSION OF FEET INTO CHAINS.

The feet are given in the body of the table, their equivalent chains in the top, and the links and decimals of links in the extreme right-hand column. The decimal parts are taken out as whole numbers, removing the decimal point in the equivalent as many places as it is removed in the original.

Example: 416·9 feet to chains

416 feet = 6 chains 30·2 links

·9 feet = 1·35 links

416·9 feet = 6 chains 31·55 links

APPENDIX I.—TABLE III. *Lineal Value in Feet of One Second of Arc and its Logarithm measured along the Meridian.*

Latitude.	Length in Feet.	Logarithm.	Diff.	Latitude.	Length in Feet.	Logarithm.	Diff.	Latitude.	Length in Feet.	Logarithm.	Diff.
° ′			+	° ′			+	° ′			+
4 0	100·7704	2·0033330	9	7 20	100·7821	2·0033835	16	10 40	100·8006	2·0034630	23
5	7706	339	9	25	7825	851	17	45	8011	653	24
10	7708	348	9	30	7829	868	17	50	8017	677	24
15	7710	357	10	35	7833	885	17	55	8022	701	24
20	7713	367	10	40	7837	902	17	11 0	8028	725	24
25	7715	377	10	45	7841	919	17	5	8034	749	24
30	7717	387	10	50	7845	936	17	10	8039	773	24
35	7719	397	11	55	7849	953	18	15	8045	797	25
40	7722	408	10	8 0	7853	971	18	20	8050	822	25
45	7724	418	11	5	7857	989	18	25	8056	847	25
50	7727	429	11	10	7861	007	18	30	8062	872	25
55	7729	440	11	15	7865	025	19	35	8068	897	26
5 0	7732	451	11	20	7870	044	18	40	8074	923	25
5	7735	462	12	25	7874	062	19	45	8080	948	26
10	7737	474	11	30	7878	081	19	50	8086	974	26
15	7740	485	12	35	7883	100	19	55	8092	2·0035000	26
20	7743	497	12	40	7887	119	19	12 0	8098	026	26
25	7745	509	12	45	7892	138	19	5	8104	052	27
30	7748	521	12	50	7896	157	20	10	8110	079	26
35	7751	533	13	55	7901	177	20	15	8116	105	27
40	7754	546	13	9 0	7905	2·0034197	20	20	8122	132	27
45	7757	559	13	5	7910	217	20	25	8129	159	27
50	7760	572	13	10	7914	237	20	30	8135	186	27
55	7763	585	13	15	7919	257	21	35	8141	213	28
6 0	7766	598	13	20	7924	278	20	40	8148	241	27
5	7769	611	14	25	7929	298	21	45	8154	268	28
10	7772	625	14	30	7934	319	21	50	8160	296	28
15	7776	639	14	35	7939	340	22	55	8167	324	28
20	7779	653	14	40	7944	362	21	13 0	8173	352	28
25	7782	667	15	45	7949	383	22	5	8180	380	29
30	7786	682	14	50	7953	405	21	10	8187	409	28
35	7789	696	15	55	7959	426	22	15	8193	437	29
40	7792	711	15	10 0	7964	448	22	20	8200	466	29
45	7796	726	15	5	7969	470	22	25	8206	495	29
50	7799	741	15	10	7974	492	22	30	8213	524	29
55	7803	756	16	15	7979	514	23	35	8220	553	30
7 0	7806	772	15	20	7984	537	23	40	8227	583	30
5	7810	787	16	25	7990	560	23	45	8234	613	30
10	7814	803	16	30	7995	583	23	50	8241	643	30
15	7817	819	16	35	8000	606	24	55	8248	673	30
								14 0	8255	703	

Appendix I.—Table IV. *Linear Value in Feet of One Second of Arc and its Logarithm along Parallels of Latitude.*

Latitude.	Length in Feet.	Diff.	Logarithm.	Diff.	Latitude.	Length in Feet.	Diff.	Logarithm.	Diff.	Latitude.	Length in Feet.	Diff.	Logarithm.	Diff.
° ′					° ′					° ′				
4 0	101·2083	103	2·0052163	443	7 30	100·5917	193	2·0025620	831	11 0	99·6021	281	1·9982686	1225
5	1980	105	1720	453	35	5724	194	4789	840	5	5740	283	1461	1234
10	1875	108	1267	462	40	5530	197	3949	849	10	5457	285	0227	1244
15	1767	110	0805	471	45	5333	199	3100	859	15	5172	287	8983	1253
20	1657	112	0334	480	50	5134	200	2241	867	20	4885	289	7730	1263
25	1545	113	2·0049854	489	55	4934	203	1374	878	25	4596	291	6467	1271
30	1432	116	9365	498						30	4305	294	1·9975196	1282
35	1316	119	8867	507	8 0	4731	206	0496	887	35	4011	295	3914	1290
40	1197	120	8360	518	5	4525	207	2·0019609	895	40	3716	297	2624	1301
45	1077	122	7842	525	10	4318	209	8714	906	45	3419	300	1323	1310
50	0955	125	7317	536	15	4109	211	7808	913	50	3119	302	0013	1320
55	0830	127	6781	544	20	3898	214	6895	924	55	2517	304	8693	1329
					25	3684	215	5971	933					
5 0	0703	128	6237	544	30	3469	218	5038	943	12 0	2513	305	1·9967364	1338
5	0575	131	5684	563	35	3251	220	4095	951	5	2208	308	6026	1349
10	0444	134	5121	572	40	3031	222	3144	962	10	1900	311	4677	1358
15	0310	135	4549	581	45	2809	224	2182	970	15	1589	312	3319	1367
20	0175	137	3968	591	50	2585	226	1212	980	20	1277	314	1952	1377
25	0038	139	3377	599	55	2359	229	0232	989	25	0963	316	0575	1387
30	100·9899	142	2778	608						30	0647	319	1·9959118	1396
35	9757	143	2170	618	9 0	2130	230	2·0009243	999	35	0328	320	7792	1405
40	9611	146	1552	628	5	1900	232	8244	1007	40	0008	323	6337	1415
45	9468	148	0924	636	10	1668	235	7237	1017	45	98·9685	324	4972	1425
50	9320	150	0288	645	15	1433	237	6220	1027	50	9361	327	3647	1435
55	9170	153	2·0039643	656	20	1196	238	5193	1036	55	9034	329	2123	1444
					25	0958	241	4157	1046					
6 0	9017	154	8987	663	30	0717	243	3111	1055	13 0	8705	331	0668	1454
5	8863	156	8324	674	35	0474	245	2056	1063	5	8374	333	1·9949214	1463
10	8707	159	7650	682	40	0229	248	0993	1074	10	8041	335	7751	1473
15	8548	160	6968	692	45	99·9981	249	1·9999919	1083	15	7706	337	6278	1482
20	8388	163	6276	701	50	9732	251	8836	1092	20	7369	339	4796	1493
25	8225	165	5575	710	55	9481	254	7744	1102	25	7030	341	3303	1502
30	8060	167	4865	720						30	6689	344	1801	1511
35	7893	169	4145	728	10 0	9227	255	6642	1111	35	6345	345	0290	1521
40	7724	171	3417	738	5	8972	258	5531	1121	40	6000	347	1·9938769	1531
45	7553	173	2679	747	10	8714	260	4410	1129	45	5653	350	7238	1541
50	7380	176	1932	757	15	8454	262	3281	1140	50	5303	352	5697	1550
55	7204	178	1175	766	20	8192	264	2141	1149	55	4951	354	4147	1560
					25	7928	266	0992	1159					
7 0	7026	179	0409	775	30	7662	268	1·9989833	1167	14 0	4587		2587	
5	6847	182	2·0029634	785	35	7394	271	8666	1177					
10	6665	184	8849	793	40	7123	272	7489	1187					
15	6481	186	8056	803	45	6851	275	6302	1196					
20	6295	188	7253	811	50	6576	276	5106	1205					
25	6107	190	6442	822	55	6300	279	3901	1215					

Appendix I.—Tables V. and VI.

For Determining Secondary Heights with the Aneroid, (compiled from Bailey's Tables).

Table V.—*Value of $t+t'$. Thermometers in Shade in Open Air, Degrees Fahrenheit.*

$t+t'$	A.	$t+t'$	A.	$t+t'$	A.
140	**4·81385**	157	4·82335	171	4·83072
141	429	158	379	175	115
142	474	159	423	176	158
143	518	**160**	**4·82466**	177	201
144	563	161	510	178	244
145	807	162	553	179	287
146	851	163	597	**180**	**4·83330**
147	895	164	641	181	373
148	940	165	684	182	416
149	984	166	727	183	458
150	**4·82028**	167	770	184	501
151	072	168	814	185	544
152	116	169	857	186	587
153	160	**170**	**4·82900**	187	630
154	204	171	943	188	672
155	248	172	986	189	715
156	292	173	4·83029	**190**	**4·83758**

Table VI.—*Latitude of the Place.*

Latitude.	*C.*	*Latitude.*	*C.*	*Latitude.*	*C.*
°		°		°	
0	0·00117	35	0·00040	70	$\bar{1}$·99910
5	115	40	20	75	00
10	110	45	0·00000	80	$\bar{1}$·99890
15	101	50	$\bar{1}$·99980	85	85
20	90	55	60	90	83
25	75	60	42		
30	58	65	25		

Appendix I.—Table VII.

Co-ordinates of Projection for 15′ Squares. Scale $\frac{1}{62{,}500}$

Latitude.	"m" on Meridian.	"n" on Parallel.	"q" on Diagonal.	Latitude.	"m" on Meridian.	"n" on Parallel.	"q" on Diagonal.
° ′	Inches.	Inches.	Inches.	° ′	Inches.	Inches.	Inches.
4 0	17·413	17·489	21·677	9 0	17·416	17·317	24·556
15	413	483	673	15	417	305	548
30	414	478	670	30	417	292	539
45	414	471	665	45	417	280	530
5 0	414	465	660	10 0	418	267	521
15	414	458	655	15	418	253	512
30	414	451	650	30	418	240	503
45	414	444	645	45	419	226	493
6 0	414	436	640	11 0	419	211	483
15	414	428	634	15	420	197	473
30	415	419	628	30	420	182	462
45	415	411	622	45	420	166	452
7 0	415	401	615	12 0	421	151	441
15	415	392	608	15	421	135	431
30	415	382	601	30	421	118	420
45	415	372	594	45	422	102	408
8 0	416	362	587	13 0	422	085	396
15	416	351	580	15	422	068	384
30	416	340	572	30	422	050	372
45	416	329	564	45	422	032	359
9 0		317		14 0		014	

Appendix I.—Table VIII.

Aneroid Corrections (Ilaro, 1911).

Time.	*Feet Altitude.*	*Time.*	*Feet Altitude.*
6.30 a.m.	+25	12.30 p.m.	− 8
7.0 ,,	33	1.0 ,,	22
7.30 ,,	40	1.30 ,,	36
8.0 ,,	52	2.0 ,,	47
8.30 ,,	58	2.30 ,,	55
9.0 ,,	61	3.0 ,,	61
9.30 ,,	61	3.30 ,,	62
10.0 ,,	57	4.0 ,,	58
10.30 ,,	49	4.30 ,,	52
11.0 ,,	39	5.0 ,,	47
11.30 ,,	24	5.30 ,,	40
12.0 noon.	9	6.0 ,,	28

Appendix I.—Table IX.

Links into Feet.

Links.	*Feet.*	*Links.*	*Feet.*	*Links.*	*Feet.*
1	·660000	34	22·440000	67	44·220000
2	1·320000	35	23·100000	68	44·880000
3	1·980000	36	23·760000	69	45·540000
4	2·640000	37	24·420000	70	46·200000
5	3·300000	38	25·080000	71	46·860000
6	3·960000	39	25·740000	72	47·520000
7	4·620000	40	26·400000	73	48·180000
8	5·280000	41	27·060000	74	48·840000
9	5·940000	42	27·720000	75	49·500000
10	6·600000	43	28·380000	76	50·160000
11	7·260000	44	29·040000	77	50·820000
12	7·920000	45	29·700000	78	51·480000
13	8·580000	46	30·360000	79	52·140000
14	9·240000	47	31·020000	80	52·800000
15	9·900000	48	31·680000	81	53·460000
16	10·560000	49	32·340000	82	54·120000
17	11·220000	50	33·000000	83	54·780000
18	11·880000	51	33·660000	84	55·440000
19	12·540000	52	34·320000	85	56·100000
20	13·200000	53	34·980000	86	56·760000
21	13·860000	54	35·640000	87	57·420000
22	14·520000	55	36·300000	88	58·080000
23	15·180000	56	36·960000	89	58·740000
24	15·840000	57	37·620000	90	59·400000
25	16·500000	58	38·280000	91	60·060000
26	17·160000	59	38·940000	92	60·720000
27	17·820000	60	39·600000	93	61·380000
28	18·480000	61	40·260000	94	62·040000
29	19·140000	62	40·920000	95	62·700000
30	19·800000	63	41·580000	96	63·360000
31	20·460000	64	42·240000	97	64·020000
32	21·120000	65	42·900000	98	64·680000
33	21·780000	66	43·560000	99	65·340000

Note.—For 100 links, multiply value of 1 link by 100.
For 200 links, multiply value of 2 links by 100.
etc. etc. etc.

For 54,000 links, multiply value of 54 links by 1000.
etc. etc. etc.

For 3·7 links, divide value of 37 links by 10.
etc. etc. etc.

Appendix I.—Table X.

Natural Tangents.

′	0°	1°	2°	3°	4°	5°	6°
0	0000	0175	0349	0524	0699	0875	1051
5	0015	0189	0364	0539	0714	0890	1066
10	0029	0204	0378	0553	0729	0904	1080
15	0044	0218	0393	0568	0743	0919	1095
20	0058	0233	0407	0582	0758	0934	1110
25	0073	0247	0422	0597	0772	0948	1125
30	0087	0262	0437	0612	0787	0963	1139
35	0102	0276	0451	0626	0802	0978	1154
40	0116	0291	0466	0641	0816	0992	1169
45	0131	0306	0480	0655	0831	1007	1184
50	0145	0320	0495	0670	0846	1022	1198
55	0160	0335	0509	0685	0860	1036	1213

′	7°	8°	9°	10°	11°	12°	13°
0	1228	1405	1584	1763	1944	2126	2309
5	1243	1420	1599	1778	1959	2141	2324
10	1257	1435	1614	1793	1974	2156	2339
15	1272	1450	1629	1808	1989	2171	2355
20	1287	1465	1644	1823	2004	2186	2370
25	1302	1480	1659	1838	2019	2202	2385
30	1317	1495	1673	1853	2035	2217	2401
35	1331	1509	1688	1868	2050	2232	2416
40	1346	1524	1703	1883	2065	2247	2432
45	1361	1539	1718	1899	2080	2263	2447
50	1376	1554	1733	1914	2095	2278	2462
55	1391	1569	1748	1929	2110	2293	2478

′	14°	15°	16°	17°	18°	19°	20°
0	2493	2679	2867	3057	3249	3443	3640
5	2509	2695	2883	3073	3265	3460	3656
10	2524	2711	2899	3089	3281	3476	3673
15	2540	2726	2915	3105	3298	3492	3689
20	2555	2742	2931	3121	3314	3508	3706
25	2571	2758	2946	3137	3330	3525	3722
30	2586	2773	2962	3153	3346	3541	3739
35	2602	2789	2978	3169	3362	3558	3755
40	2617	2805	2994	3185	3378	3574	3772
45	2633	2820	3010	3201	3395	3590	3789
50	2648	2836	3026	3217	3411	3607	3805
55	2664	2852	3041	3233	3427	3623	3822

APPENDIX II.

(Public Notice No. 94 of 22nd April 1911.)

CONDITIONS OF ENTRY, SURVEY SCHOOL, SOUTHERN NIGERIA SURVEY.

1. This Notice cancels Public Notice No. 55 of the 27th of March 1908.

2. By recent changes in the Regulations, and by promotions, the posts of "Surveyor" and "Draftsman" in the Southern Nigeria Survey have been considerably advanced in value, both as regards salary and future prospects.

3. The following are the grades and rates of surveyors and draftsmen :—

	Surveyors.	Draftsmen.
Chief Native . .	£200–10—250	£164–12—204
1st Class . . .	96—6—150	96—6—150
2nd ,, . . .	72—6— 90	72—6— 90
3rd ,, . . .	48—6— 60	48—6— 60
4th ,, . . .	40—4— 48	40—4— 48

4. To obtain one of the above-mentioned appointments, a candidate is required to go through a course of instruction at the Survey School for three years for surveyors and two years for draftsmen.

The first year is practically devoted to school instruction, but during the second and third years the pupils join the field camps for practical instruction.

At the end of the first year, a proportion of the pupils are selected for training as cadastral surveyors, and the remainder join the Topographical Branch.

Promotion to 2nd and 1st Class Surveyorships of surveyors of lower grade is conditional on the passing of a satisfactory examination, after special courses of instruction held in the School during the field recesses.

The Syllabus of Instruction at the School can always be seen in the Chief Instructor's office.

5. Examination for Surveyors' Class. The examination for entrance to the Survey School for those wishing to become surveyors will be held on 24th July 1911, at the Survey School, Broad Street. Applications to be sent to the Director of Surveys by 30th June, accompanied by the letters referred to in 6 (b).

The new class will consist of eight pupils, who will be selected both by results of the examination and their general physique and intelligence. The class will be required to begin work on 30th September.

6. Qualifications of Candidates for the Surveyors' Class, Survey School.

(a) Candidates must not be under sixteen years of age.

(b) Candidates must furnish two certificates of character, one of which should be from the Principal of the School last attended.

(c) Candidates must have an elementary knowledge of Algebra, Euclid, and Mensuration.

7. Qualifications for Draftsmen's Class, Survey School.

(a) Candidates must not be under fourteen years of age.

(b) As in 6 (b).

(c) As in 6 (c).

8. Draftsmen's Class. Appointment to the Drafting Class is by special selection, and candidates are only required to pass a brief examination to test their intelligence, knowledge of elementary mathematics, and handwriting.

The Draftsmen's Class is at present complete, and vacancies therein will be notified in the Gazette as they occur.

A vacancy can sometimes be found for an especially promising applicant.

9. An allowance to pupils attending the Surveyors' Class will be granted as follows, so long as their conduct is satisfactory :—

1st year	£20
2nd „	£30
3rd „	£35

The draftsmen pupils will be allowed a small amount monthly according to their progress and conduct, such amount being decided by the Director of Surveys.

10. Pupils in the Surveyors' Class will be required to enter into a bond to remain in the Public Service for a period of three years after the completion of a course of instruction of three years at the School, and draftsmen for four years after two years instruction.

11. All pupils will be on probation for their first three months of instruction. If at the end of this period any candidate fails to prove himself sufficiently promising a pupil he will not be retained in the School.

12. Pupils whose behaviour or progress does not give satisfaction either during the course of instruction or in their subsequent period of service are liable to summary discharge by the Government.

13. All pupils, surveyors, and draftsmen in the Southern Nigeria Survey are bound by the Rules and Regulations laid down in the "Handbook," Southern Nigeria Survey, in addition to the usual Colonial Regulations.

APPENDIX III.

SURVEY SCHOOL COURSE OF INSTRUCTION.

1. At the end of the first year's instruction a certain number of pupils will be selected for training as cadastral surveyors.

2. *Junior Class Course.*—(Length of Course eleven months; Leave one month):—

Practical Geometry; very Simple Trigonometry; Lettering and Conventional Signs; Scales; Geometrical Drawing; Use of Logarithms; the Simple Principles of Compass Surveys; Tertiary Compass Traverses; Rope and Compass Traverses; the Use of Plane Table as a Survey Instrument as far as Secondary and Tertiary Plane-table Traversing; Chaining; Keeping Field Books; the Use of Compass, Clinometer, and Aneroid Barometer; Secondary and Tertiary Heights and Aneroid Levels; Approximate Contouring (*i.e.*, Form-lines); Co-ordinates from Latitude and Departure Tables; Plotting by Protractor; Plotting by Co-ordinates; Simple Reduction and Enlargement of Maps.

3. *Middle Class Course.*—(Length of Course, in the Field eight months; in School three months; Leave one month.)

Topographical Branch pupils will only have about three months' instruction in the School at the end of the Field Season. During this time they will be taught—

Primary and Secondary Compass Traverses; Use and Adjustment of a Level; Running a Topographical Level; Plane-table Surveying; Approximate Contouring with Plane Table and Compass; Solution of Simple Triangles; Calculation of Latitudes and Departures; Graticule Drawing and Plotting Fixed Points as laid down in the "Handbook."

4. In addition to the above course, the Middle Class cadastral pupils will be taught the following subjects during about eight months' schooling, the remaining three months, besides the annual holiday, being spent with cadastral parties in actual town survey:—

Use of Theodolite; Theodolite Traverses; Town Survey and Maps; Accurate Contouring with Theodolite, Level, and Water Level.

5. *Senior Class Course.*—(Length of Course, in the Field eight months; in School three months; Leave one month.)

During the three months in the School at the end of their second Field Season, the topographical pupils will be taught the following subjects:—

Use of Theodolite; Theodolite Traverses; Accurate Contouring with Theodolite, Level, and Water Level; Amplitude Computations; Triangulation.

6. The cadastral pupils of the Senior Class will spend about three months of their third year with cadastral parties in Town Surveys. Their eight months in the School will consist of:—

Triangulation; Town Surveys; Theory of Mining Surveys; Railway Surveys; Marine Surveys.

Special Classes.

7. Before promotion to a higher grade than Third-class Surveyor, native surveyors will be required to pass certain examinations, courses for which will be held during the Recess in the School.

Topographical surveyors will be required to pass an examination in Field Astronomy and Railway Surveys; cadastral surveyors will be required to pass in Field Astronomy.

Before promotion to First-class Surveyors, topographical surveyors will be required to pass an examination in Town and Marine Surveys, and in the Theory of Mining Surveys.

Before promotion to Chief Native Surveyors, all surveyors will be required to pass an examination in all Survey subjects.

8. Owing to the topographical pupils being attached to field camps for the Field Season during their second and third years, the C.I.S. will be able to devote his entire attention to the Junior Class and to the few cadastral pupils left in the School. He should endeavour to arrange for the cadastral pupils of the Middle Class being in the Field while those of the Senior are in the School, and *vice versa*.

During the Field Recess, he will be given two or more native surveyors to help him in the instruction of the School, which will naturally then be very crowded.

9. *Draftsmen's Class.*—(Length of Course twenty-two months; Leave two months.)

The following is the course :—

Use of Drawing Instruments, Tracing, etc.; Scales, their Construction and Use (Southern Nigeria Scales especially); Plotting by Protractor from Field Books, (a) Rectangular Offsets, (b) Radial Offsets; Use and Calculation of Rectangular Co-ordinates; Plotting by Co-ordinates; Conventional Signs; Lettering and Colouring; Reduction and Enlargement of Maps; Use of Pantograph and Eidograph; Drawing Graticules, and Plotting Fixed Points; Compilation of Maps from Surveys; Elementary Plane Trigonometry; Use of Logarithms and Logarithmic Tables; Solution of Triangles; Computation of Areas; Use of Planimeter; Filing Records and Keeping Record Books.

Draftsmen will be trained in equal numbers for Topographical and Cadastral Drawing.

10. It is proposed to admit eight pupils every year to the Survey School for training as surveyors and four for training as draftsmen. The Course will begin on 1st October annually.

APPENDIX IV.

EQUIPMENT OF SURVEY CAMPS.

LIST I. TOOLS.

Item	Description.	Price. (* Per Doz.)	Firm.	Group Camp.		Field Camp.				Prig. Camp.			Theod. Trav. Camp.		Lev. Camp.		Remarks.
				C.O.	Draftsman.	C.O.	Eur. Sur.	Nat. Sur.	Pupil.	C.O.	Eur. Sur.	Nat. Sur.	C.O.	Assistant.	C.O.	Assistant.	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
1	Axes. Felling. 5 lb.	£0 6 0	A. & N.C.S.	1	—	1	1	—	—		50		15		1	—	
2	Do. do. Spare Handles	0 1 0	do.	1	—	1	1	—	—		50		10		—	—	
3	Do. Hand. No. 2, 2¼ lbs.	0 2 9	do.	2	—	1	1	1	—		6		6		1	—	
4	Do. do. Spare Handles	0 0 4	do.	1	—	1	1	1	—		6		6		1	—	
5	Do. Pick	0 3 6	do.	1	—	1	1	1	—		3		2		1	—	
6	D. do. Spare Handles	0 2 0	do.	1	—	1	—	—	—	—	3	—	2		1	—	
7	†Bradawls	0 1 6*	do.	1	—	1	1	—	—	2	1	1	1	—	1	—	
8	Brushes. Sash Tool. No. 5	0 5 0*	do.	2	—	2	1	1	1	1	1	1	1	1	1	1	
9	Do. do. No. 1	0 2 0*	do.	2	—	2	1	1	1	—	—	—	1	1	1	1	

Item.	Description.	Price. (* Per Doz.)	Firm.	Group Camp.		Field Camp.				Trig. Camp.			Theod. Trav. Camp.		Lev. Camp.		Remarks.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
10	Cases. Tool, Canvas, to hold Tools marked † .	Current.	S.N.S.	1	—	1	1	1	—	1	1	1	1	—	1	—	
11	†Chisels. Wood. 1 in.	0 1 2	A. & N.C.S.	1	—	1	1	1	1	2	2	2	1	1	1	—	
12	† Do. Cold. $\frac{3}{4}$ in.	0 1 0	do.	1	—	1	1	1	1	2	2	2	1	1	1	1	
13	†Files. Wood. 12 in.	0 0 10	do.	1	—	1	1	—	—	1	1	1	1	—	1	—	
14	† Do. Metal, square. 12 in.	0 0 11	do.	1	—	1	1	1	—	2	2	2	1	—	1	—	
15	† Do. do. 4 in.	0 0 4	do.	1	—	1	1	—	—	2	2	2	1	—	1	—	
16	†Gimlets	0 0 3	do.	1	—	1	1	—	—	2	2	2	1	—	1	—	
17	Grindstones. 8 in.	0 8 6	do.	1	—	—	—	—	—	1	—	—	1	—	—	—	
18	†Hammers. Engineers' Rivetting. 1 lb. . .	0 1 3	do.	1	—	1	1	1	1	2	2	2	1	1	1	1	
19	Matchets	—	—	10	—	20	15	5	5		100			10		15	
20	†Pliers. Indispensable Combination Tool . .	0 2 6	A. & N.C.S.	1	—	1	1	1	—	2	2	2	1	—	1	—	
21	†Punches. Steel	0 0 6	do.	1	—	—	—	—	—	2	2	2	—	—	—	—	
22	†Rules. 2 ft. 4-fold	0 0 11	do.	1	—	1	1	1	—	2	2	2	1	—	1	—	
23	Saws. Cross-cut. 5 ft.	0 10 6	do.	—	—	—	—	—	—	—	—	—	1	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (* Per Doz.)	FIRM.	GROUP CAMP.	FIELD CAMP.			TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	*C.O.*	*Ear. Sur.*	*Nat. Sur.*	*C.O.*	*Ear. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
1.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
24	SAWS. Cross-cut. Spare Handles. Pairs . .	0 1 6	A. & N.C.S.	—	—	—	—	—	—	—	—	—	1	—	—	—	
25	Do. Household. 22 in.	0 2 9	do.	1	—	1	1	1	—	2	2	2	2	—	1	—	
26	SAW-SETS	0 3 3	do.	—	—	—	—	—	—	—	—	—	1	—	—	—	
27	†SCREWDRIVERS	0 1 0	do.	1	—	—	—	—	1	—	—	—	—	—	—	—	
28	†SCREWDRIVER SET. 3 blades	0 1 6	do.	1	—	1	1	1	—	1	1	1	1	—	1	—	
29	SOLDERING SET of—	0 13 0	do.	1	—	—	—	—	—	1	—	—	1	—	—	—	
29a	2 Irons at 1/-																
29b	1 Lamp Roarer at 7/6																
29c	3 Bottles Fluid at 6d.																
29d	2 lbs. Solder at 1/-																
30	SPADES. No. 3	0 3 0	do.	1	—	1	1	1	—	1	1	1	1	—	1	—	
31	STONES. Oil	0 1 3	do.	1	—	1	1	1	—	1	1	1	1	—	1	—	
32	TROWELS. Masons'. 7 in.	0 1 9	do.	1	—	1	1	1	—	2	2	2	1	1	1	1	
33	WEDGES. Iron. lb.	0 0 5	do.	—	—	—	—	—	—	3	3	3	3	—	—	—	

Appendix IV.—List II. Expense Stores.

Item.	Description.	Price. (*Per Doz.)	Firm.	Group Camp.		Field Camp.				Trig. Camp.			Theod. Trav. Camp.		Lev. Camp.		Remarks.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
34	Beacons. Survey, Topographical	—	—	10	—	50	—	—	—	—	—	—	*	—	*	—	According to requirements.
35	Do. do. Cadastral	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
36	Bunting. White. Yds.	£0 19 3 per 40 yds.	A. & N.C.S.	5	—	5	—	—	—	50	—	—	—	—	—	—	
37	Do. Red. Yds.	1 0 6 per 40 yds.	do.	5	—	5	—	—	—	—	—	—	½	—	½	—	
38	Canvas. Willesden. 43 in., yds.	0 3 0	do.	5	—	5	—	—	—	10	—	—	2	—	2	—	
39	Calico. Unbleached. 72 in., yds.	0 0 11	do.	—	—	—	—	—	—	30	—	—	—	—	—	—	
40	Cement. 28 lb. tins	0 1 2	do.	—	—	—	—	—	—	20	—	—	—	—	—	—	
41	Nails. Wire. 2 in., lbs.	0 0 2	do.	1	—	1	—	—	—	10	—	—	½	—	½	—	
42	Do. do. 3 in., lbs.	0 0 2	do.	1	—	1	—	—	—	10	—	—	½	—	½	—	
43	Oil. Kerosene. 18 gall. cases	Current	Lagos	3	—	3	3	1	1	3	3	1	3	1	3	1	
44	Do. Rangoon. Tins, screw-top	0 0 10	A. & N.C.S.	1	—	1	—	—	—	1	—	—	1	—	1	—	
45	Paint. White. 1 lb. lever tins	0 4 6*	do.	8	—	12	—	—	—	4	—	—	4	—	4	—	
46	Do. Red. 1 lb. lever tins	0 4 6*	do.	8	—	12	—	—	—	4	—	—	4	—	4	—	
47	Pins. Iron. 15 in.	—	—	—	—	—	—	—	—	50	—	—	—	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII	XVIII.
48	PINS. Iron. 6 in.									50							
49	ROPE. $\frac{3}{4}$ in. 43 ft. Per lb., lbs.	£2 18 6 per cwt.	A. & N.C.S.	2	—	2	—	—	—	2	—	—	2	—	2	—	
50	Do. 1 in. 33 ft. Per lb., lbs.	2 18 6 per cwt.	do.	—	—	—	—	—	—	560	—	—	—	—	—	—	
51	Do. 2 in. 7½ ft. Per lb., lbs.	2 18 6 per cwt.	do.	—	—	—	—	—	—	560	—	—	—	—	—	—	
52	Do. Tent. Fathoms	2 7 0 per cwt.	do.	10	—	—	—	—	—	5	—	—	—	—	—	—	
53	SCREWS. 1½ in. Doz.	0 2 9 per gross	do.	3	—	3	—	—	—	6	—	—	1	—	1	—	
54	SPUN YARN. 1 lb. hanks	0 1 1	do.	1	—	1	—	—	—	10	—	—	1	—	1	—	
55	TACKS. Tin. 1 lb. boxes	0 0 5½	do.	1	—	1	—	—	—	1	—	—	1		1	—	
56	VASELINE. Veterinary. 1 lb. tins	0 0 7	do.	4	—	4	—	—	—	8	—	—	2	—	1		
57	WIRE. 28 lb. loads	8 5 0 per ½ ton	do.	—	—	—	—	—	—	40	—	—	—	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	*Draftsman.*	*C.O.*	*Asst. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Asst. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
58	ALIDADES. "Close-Brooker," with Racked Diagonal and Straight Eye-pieces.	£17 4 0	Cary Porter	—	—	—	1	1	—	1	—	—	—	—	—	—	
59	Do. do. do. plus Micro. Eye-piece .	20 14 0	do.	1	—	1	—	—	—	—	—	—	—	—	—	—	
60	ARROWS. Galvanised Iron. Sets of 10 . . .	0 1 3	Steward	1	—	1	1	1	1	1	1	—	1	—	1	1	
61	BAROMETERS. Aneroid. 2·7 in.	4 4 0	do.	2	—	2	1	1	1	1	1	1	1	1	1	1	
62	Do. do. 3 in.	7 15 0	do.	—	—	—	—	—	—	1	—	—	1	—	—	—	
63	Do. do. 4 in.		—	1	—		—	—	—	—	—	—					
64	Do. do.		—	—	—	—	—	—	—	—	—	—	—	—	—	—	
65	Do. do. 2·7 in., Sling Cases for .	0 8 6	Steward	2	—	2	1	1	1	1	1	1	1	1	1	1	
66	BANDS. Steel. 200 ft. $\frac{1}{8}$ in., marked every foot, 15-lb. pull, 65° Fahr.	2 5 0	Cary Porter	1	—	1	1	1	—	1	—	—	2	—	1	—	
67	Do. do. do. (Standard only) . .	2 5 0	do.	1	—	1	—	—	—	—	—	—	1	—	1	—	
68	Do. do. 66 ft., $\frac{1}{8}$ in., marked every link .	1 10 0	do.	2	—	—	—	—	—	—	—	—	—	—	—	—	
69	Do. do. Repair Cases	0 10 0	do.	2	—	1	—	—	—	1	—	—	1	—	1	—	
70	BARS. Subtense. Southern Nigeria Survey Pattern	—	do.	—	—	—	—	—	—	—	—	—	3*	—	—	—	When on river traverse.
71	CHRONOMETERS	—	do.	—	—	—	—	—	—	—	—	—	—	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	*Draftsman.*	*C.O.*	*Ever. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Ever. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
72	COMPASSES. Prismatic. Mark I. 1 in., with Aluminium Ring, Leather Sling Case, and Tripod complete.	£5 19 0	Cary Porter	1	—	1	1	—	—	—	—	—	—	—	1	—	
73	Do. Prismatic. Mark II. 3 in., with Aluminium Ring, Sling Case, and Tripod.	3 1 6	do.	1	—	—	—	1	1	1	1	1	1	1	1	1	
74	Do. Prismatic. 5 in.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	
75	Do. do. Marks I. and II. Spare Sling Cases.	0 10 6	Cary Porter	—	—	—	—	—	—	—	—	—	—	—	—	—	
76	Do. do. Marks I. and II. Spare Tripods.	1 3 0	do.	—	—	—	—	—	—	—	—	—	—	—	—	—	
77	FIELD GLASSES	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	
78	FIELD TELESCOPES. "N.C.O."	1 10 0	Steward	—	—	—	—	—	—	1	1	—	—	—	—	—	
79	FLASHLIGHTS. "Ever Ready"	0 16 6	A. & N.C.S.	2	—	—	—	—	—	4	—	—	—	—	—	—	
80	Do. Refills	0 1 6	do.	8*	—	—	—	—	—	16*	—	—	—	—	—	—	* Periodic supply, monthly.
81	HELIOGRAPHS. "Territorial, 3 in." . . .	6 10 0	Steward	—	—	—	—	—	—	2	1	1	—	—	—	—	
82	HELIOSTADTS	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	
83	LEVELS. Abney. No. K229	1 15 0	Steward	1	—	1	1	1	1	1	1	1	1	1	1	—	
84	Do. Dumpy. 14 in.	16 0 0	Cary Porter	—	—	—	—	—	—	1	—	—	—	—	1	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
85	PLANE TABLES. Mark I. 18 by 18 in. Board, Alidade, Metal Trough Compass, Cover, Waterproof Case, and Tripod.	£3 17 6	Steward	—	—	—	—	—	1	—	1	1	—	1	—	1	
86	Do. Mark II. 20 by 24 in. Board, complete as Mark I.	7 10 0	Cary Porter	—	—	1*	1*	1	—	1	—	—	—	—	—	—	* Alternative, according to stock.
87	Do. Mark II. Spare Boards . .	1 10 0	do.	—	—	3†	—	—	—	—	—	—	—	—	—	—	
88	Do. Mark III. 24 by 24 in. Board, complete as Mark II., but with Southern Nigeria Survey Pattern Tripod.	15 8 6	do.	1	—	1*	1*	—	—	—	—	—	—	—	—	—	† According to class of plane table.
89	Do. Mark III. Spare Boards . .	2 16 0	do.	—	—	—	—	—	—	—	—	—	—	—	—	—	
90	Do. Zinc Tops. 12 lb., and Clamps.	1 0 0	do.	3	—	3†	—	—	—	—	—	—	—	—	—	—	
91	Do. Mark IV. 20 by 20 in. Board, complete as Mark I.	4 7 6	Steward	—	—	—	—	—	—	—	—	—	—	—	—	—	To replace Mark I.
92	PLUMBOBS. Brass. 6 oz.	0 5 0	do.	1	—	1	—	—	—	2	2	1	1	1	—	1	
93	RODS. Ranging. 8 ft	2 0 0*	do.	6	—	3‡	3‡	3‡	3	10	—	—	6	—	6	—	‡ Double in plane-table survey.
94	ROPES. Survey. Steel. 310 ft., $\frac{3}{8}$ in. diameter .	1 9 9	Cary Porter	1	—	1	1	1	1	—	—	—	—	—	—	—	
95	Do. do. do. do. Reels for	0 3 6	do.	1	—	1	1	1	1	—	—	—	—	—	—	—	
96	Do. Water Survey. Steel. 1000 ft. 18 lbs. .	4 0 0	do.	1	—	—	—	—	—	—	—	—	—	—	—	—	
97	Do. do. do. do. Reels for	1 10 0	do.	1	—	—	—	—	—	—	—	—	—	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	Draftsmen.	C.O.	Asst. Surv.	Nat. Surv.	Pupil.	C.O.	Asst. Surv.	Nat. Surv.	C.O.	Assistant.	C.O.	Assistant.	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV	XVI.	XVII.	XVIII.
98	ROPES. Water Survey. Steel. 1000 ft. 18 lbs. Corks for, 3½ by 1½ in.	£0 3 6*	Cary Porter	120	—	—	—	—	—	—	—	—	—	—	—	—	
99	Do. Lead Line. 1000 ft.	2 2 0	A. & N.C.S.	Made up locally when Steel Ropes exhausted.													
100	RULES. Steel. 1 ft., marked in $\frac{1}{20}$ths of a foot	0 1 6	Cary Porter	1	—	1	1	1	—	1	—	—	1	—	1	—	
101	SPRING BALANCES. 25 lbs.	0 2 0	Steward	1	—	1	1	1	—	—	—	—	1	—	1	—	
102	THEODOLITES. 6 in. Micro.	44 0 0	Troughton & Simms	—	—	—	—	—	—	2	—	—	1	—	—	—	* If on river traverse.
103	Do. 5 in. Micro.	12 0 0	do.	2	—	—	—	—	—	1	—	—	2	—	—	—	
104	Do. Extra Leather Cases, Padded Inside, Knapsack Sling. Pairs	5 10 0 per pair.	do.	2	—	—	—	—	—	3	—	—	2	—	—	—	Provided with all theodolites as funds permit.
105	Do. Extra Leather Cap for Stand	0 16 6	do.	2	—	—	—	—	—	3	—	—	2	—	—	—	
106	Do. Spare Stand	5 0 0	do.	—	—	—	—	—	—	—	—	—	—	—	—	—	
107	Do. 3 in. Complete	22 10 0	do.	—	—	—	—	—	—	—	—	—	—	—	—	—	
108	THERMOMETERS	0 3 6	Steward	2	—	2	1	1	1	2	1	1	2	1	1	1	
109	UMBRELLAS. Surveyors'	1 13 0	Cary Porter	1	—	1	1	1	—	1	1	1	1	—	1	—	
110	WATCHES. Pocket. "A" Model	0 11 6	A. & N.C.S.	2	—	1	1	1	1	1	1	1	1	—	1	—	
111	Do. Deck. Chronometer	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	
112	WHISTLES. Plated	0 0 6	A. & N.C.S.	5	—	1	1	1	1	—	—	—	—	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
113	BOARDS. Drawing. 32 by 23 in.	£0 9 6	Steward	1	—	1	1	1	—	1	—	—	1	—	1	—	
114	Do. do. Large size	Current	S.N.S.	—	1	—	—	—	—	—	—	—	—	—	—	—	
115	Do. do. do. Trestles for . .	do.	do.	—	1	—	—	—	—	—	—	—	—	—	—	—	
116	CASES. Plan. 4 by 36 in.	0 2 6	A. & N.C.S.	4	—	2	1	1	1	3	1	1	2	—	2	—	
117	COMPASSES. Beam. Sets	0 15 6	Steward	—	1	1	1	—	—	1	—	—	—	—	—	—	
118	Do. do. Laths for. 24 in. . . .	0 0 7	do.	—	1	—	1	—	—	—	—	—	—	—	—	—	
119	Do. do. do. 36 in. . . .	0 1 0	do.	—	1	1	—	—	—	1	—	—	—	—	—	—	
120	Do. Proportional	0 8 6	do.	1	1	1	1	1	1	1	—	—	1	—	1	—	
121	Do. Sping-Bow. Sets	0 8 6	do.	1	—	—	—	—	—	—	—	—	—	—	—	—	
122	ERASERS. A. and N. Red	0 0 3	A. & N.C.S.	12	—	3	1	1	1	6	1	1	3	1	3	1	
123	INK. Indian. Higgins. $\frac{3}{4}$ oz. botts. . . .	0 0 9	do.	6	—	1	1	1	1	3	1	1	3	1	3	1	
124	Do. Red. Higgins. $\frac{3}{4}$ oz. botts. . . .	—	—	3	—	1	1	1	1	1	—	—	1	—	1	—	
125	Do. Blue. do. do.	—	—	3	—	1	1	1	1	1	—	—	1	—	1	—	
126	Do. Green. do. do.	—	—	3	—	1	1	1	1	1	—	—	1	—	1	—	
127	Do. Brown. do. do.	—	—	3	—	1	1	1	1	1	—	—	1	—	1	—	
128	INSTRUMENTS. Drawing. Roll Cases. Southern Nigeria Survey Pattern	1 9 6	Steward	1	1	1	1	1	1	1	1	1	1	—	1	—	

Item.	Description.	Price. (*Per Doz.)	Firm.	Group Camp.		Field Camp.				Trig. Camp.			Theod. Trav. Camp.		Lev. Camp.		Remarks.
				C.O.	*Draftsman.*	*C.O.*	*Ear. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Ear. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
129	Magnifiers. Pocket	£0 3 6	Steward	1	1	1	1	1	–	1	–	–	1	–	1	–	
130	Measurers. Map. Miles, 1:62,500	0 1 6	do.	1	—	—	—	—	–	1	–	—	—	—	—	—	
131	Pantagraphs. Brass. 24 in. Tubular	8 10 0	do.	—	1	—	–	–	–	–	–	–	–	–	–	–	
132	Do. Wood. 18 in.	2 15 0	do.	1	—	1	–	–	–	–	—	—	—	–	–	–	
133	Paint. Water Colour. Boxes	0 7 6	do.	1	1	1	1	1	1	1	–	–	1	–	1	–	
134	Do. do. Spare Pans. Red	0 0 6	do.	—	2	2	—	—	—	1	–	–	1	–	1	–	
135	Do. do. do. Blue	0 0 6	do.	—	2	2	—	—	—	1	–	–	1	–	1	–	
136	Do. do. do. Brown	0 0 6	do.	—	2	2	—	—	—	1	–	–	1	–	1	–	
137	Do. do. do. Green	0 0 6	do.	—	2	2	—	—	–	1	–	–	1	–	1	–	
138	Do. do. Brushes. Sable. No. 2	0 0 6	do.	3	3	3	3	3	2	3	–	–	3	–	3	–	
139	Paper. Cartridge. Whatman's best. Double-Elephant 40 by 27 in. Sheets	0 19 0 per quire	do.	12	—	4	–	–	–	12	–	–	–	–	–	–	
140	Do. Sectional. Mounted. Auxiliary Sheets. 18 by 18 in. Quires	0 17 0	Johnston	4	—	1	1	1	1	3	–	–	2	–	2	–	According to Mark of Plane Table.
141	Do. do. do. 20 by 20 in. Quires	0 18 0	do.														
142	Do. do. do. 20 by 24 in. Quires	0 19 0	do.														
143	Do. do. do. 24 by 24 in. Quires	1 1 0	do.														
144	Do. Tracing. White. 30 in. by 21 yds. Rolls	0 7 0	Steward	5	—	½	½	—	—	1	–	–	½	–	½	–	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
145	PAPER. Tracing. Cloth. 30 in. by 24 yds. Rolls	£1 1 0	Steward	1	—	½	½	—	—	1	—	—	½	—	½	—	
146	PAPER PADS. Sectional. ⅛ in.	0 1 6	Johnston	1	—	1	—	—	—	1	—	—	1	—	—	—	
147	PENCILS. Koh-i-noor. H.B. Pkts. . . .	0 3 6*	A. & N.C.S.	6	—	1	1	1	1	1	1	1	1	1	1	1	
148	Do. do. H. or harder. Pkts. .	0 3 6*	do.	4	—	2	½	½	½	1	½	½	1	—	1	—	
149	Do. Blue	0 1 2*	do.	2	—	2	1	1	1	6	1	1	2	—	2	—	
150	Do. Red	0 1 2*	do.	2	—	2	1	1	1	6	1	1	2	—	2	—	
151	Do. Indelible	0 1 4*	do.	2	—	4	2	2	2	6	2	2	6	—	6	—	
152	PENS. Drawing. Spare	0 2 0	Steward	—	2	—	—	—	—	—	—	—	—	—	—	—	
153	PENHOLDERS. Cedar. Taper. 7 in. . . .	0 0 3	A. & N.C.S.	2	2	1	1	1	1	1	1	1	1	1	1	1	
154	PEN NIBS. Gillott's 404. Boxes of 3 doz. . .	0 0 6	do.	1	1	1	1	—	—	2	—	—	1	—	1	—	
155	Do. Mapping. Cards of	0 0 4½	do.	4	2	2	1	1	1	6	—	—	1	—	1	—	
156	PINS. Drawing. The Perfect. No. 1. ⅝ in. Dozens.	0 0 6*	do.	2	1	1	1	1	½	6	—	—	1	—	1	—	
157	PLANIMETERS	3 0 0	Steward	—	1	—	—	—	—	—	—	—	—	—	—	—	
158	PROTRACTORS. Wood. 5 in. Southern Nigeria Survey Pattern	0 4 6	Cary Porter	2	1	1	1	1	1	1	1	1	1	1	1	1	
159	Do. Paper. Circular	0 0 6	Steward	—	1	—	—	—	—	2	—	—	—	—	—	—	
160	RULERS. Rolling. Brass. 15 in. In case . .	1 5 0	do.	1	1	1	1	1	—	—	1	1	1	—	1	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
161	RULERS. Rolling. Brass. 24 in.	£2 0 0	Steward	—	1	—	—	—	—	1	—	—	—	—	—	—	
162	Do. Straight-edge. Brass. 30 in. In case. Plain	0 16 0	do.	1	—	1	—	—	—	1	—	—	1	—	1	—	
163	Do. do. Marked in 20ths in. . . .	0 19 0	do.	—	1	—	—	—	—	—	—	—	—	—	—	—	
164	SCALES. Plotting. Wood. 24 in. 1:62,500 and 1:12,500. Feet	0 4 6	Cary Porter	1	1	1	1	1	—	1	—	—	1	—	1	—	
165	Do. do. 12 in. 1:62,500 and 1:12,500. Feet	0 2 6	do.	2	1	1	1	1	1	1	1	1	1	1	1	1	
166	Do. do. 1:5000 and 1:10,000. Feet .	0 2 6	do.	2	—	1	—	—	—	1	—	—	—	—	—	—	
167	Do. do. 1:125,000. Feet and miles .	0 2 6	do.	1	1	1	—	—	—	1	—	—	—	—	—	—	
168	Do. do. 1:250,000. Feet and miles .	0 2 6	do.	1	1	1	—	—	—	1	—	—	—	—	—	—	
169	Do. do. 1:25,000 and 1:31,250. Feet .	0 2 6	do.	1	1	1	1	1	—	1	1	—	1	—	1	—	
170	Do. do. Cardboard. 1:62,500 and 1:12,500. Feet	0 0 6	do.	4	—	4	—	—	—	—	—	—	1	—	1	—	
171	SCALE CASES. For eight 12 in. and two 24 in. Scales	Current	S.N.S.	1	1	1	1	1	—	1	—	—	1	—	1	—	
172	SET SQUARES. Transparent. 6 in., 15°, 60°. Pairs	0 1 8	Steward	1	1	1	1	1	1	1	—	—	1	—	1	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
173	ALMANACS. Nautical. Current Year . . .	£0 2 0	A. & N.C.S.	2	—	—	—	—	—	2	—	—	1	—	—	—	
174	Do. do. Next Year . . .	0 2 0	do.	2	—	—	—	—	—	2	—	—	1	—	—	—	
175	DIARIES. Special	0 2 0	do.	1	1	1	1	1	1	1	1	1	1	1	1	1	
176	FIELD BOOKS. Compass Traverse. 100 leaves .	9 10 0 per 100	Johnston	70	—	20	20	15	10	1	1	1	50	20	20	—	
177	Do. do. do. 50 leaves .	6 10 0 per 100	do.	30	—	5	5	5	5	—	—	—	5	—	5	—	
178	Do. Village. 50 leaves . . .	0 1 0	do.	20	—	2	2	2	1	—	—	—	2	—	2	—	
179	Do. River. 50 leaves	0 1 0	do.	10	—	2	1	1	1	—	—	—	2	—	2	—	
180	Do. Trigonometrical and Astronomical Angle Books	—	—	6	—	—	—	—	—	18	—	—	12	—	—	—	
181	Do. Levelling	0 1 0	S.M.E.	—	—	—	—	—	—	2	—	—	—	—	20	—	
182	FIELD NOTE BOOKS	0 1 0	Johnston	10	2	3	1	1	1	7	1	1	1	1	1	1	
	FORMS. SOUTHERN NIGERIA SURVEY:—																
183	No. 6. Requisition Book	Gov. Printer	Lagos	1	—	1	—	—	—	1	—	—	1	—	1	—	
184	No. 21. Aneroid Heights	do.	do.	50	—	50	—	—	—	20	—	—	10	—	10	—	
185	No. 22. Theodolite Traverse	do.	do.	20	—	—	—	—	—	—	—	—	100	—	—	—	
186	No. 23. Compass Traverse	do.	do.	50	—	20	—	—	—	—	—	—	—	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
	FORMS. SOUTHERN NIGERIA SURVEY (*contd.*):—																
187	No. 24. Field Book Number Slips . . .	Gov. Printer	Lagos	100	—	20	—	—	—	20		—	20	—	20	—	
188	No. 25. River Field Book Slips . . .			20	—	10	—	—	—	—	—	—	5	—	5	—	
189	No. 26. Traverse Field Book Slips . .	—	—	20	—	100	—	—	—	20	—	—	80	—	30	—	
190	No. 27. Village Field Book Slips . . .	—	—	20	—	10	—	—	—	—	—	—	5	—	5	—	
191	No. 28. Care of Beacons	Gov. Printer	Lagos	20	—	50	—	—	—	100	—	—	50	—	50	—	
192	No. 30. Field Sheet Record	do.	do.	10	—	1	—	—	—	—	—	—	—	—	—	—	
193	No. 32. Amplitude Computation . . .	do.	do.	10	—	—	—	—	—	—	—	—	20	—	—	—	
194	No. 33. Trigonometrical Table, I. . .	—	—	—	—	—	—	—	—	25	—	—	—	—	—	—	
195	No. 34. Do. do. II. . .	—	—	—	—	—	—	—	—	25	—	—	—	—	—	—	
196	No. 35. Do. do. III. . .	—	—	—	—	—	—	—	—	25	—	—	—	—	—	—	
197	No. 36. Do. do. IV. . .	—	—	—	—	—	—	—	—	25	—	—	—	—	—	—	
198	No. 37. Do. do. V. . .	—	—	—	—	—	—	—	—	25	—	—	—	—	—	—	
199	No. 38. Sun Time	—	—	40	—	—	—	—	—	20	—	—	40	—	—	—	
200	No. 39. Star Time	—	—	60	—	—	—	—	—	50	—	—	100	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				C. O.	*Draftsman.*	*C. O.*	*Enr. Sur.*	*Nat. Sur.*	*Pupil.*	*C. O.*	*Enr. Sur.*	*Nat. Sur.*	*C. O.*	*Assistant.*	*C. O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
	FORMS. SOUTHERN NIGERIA SURVEY (*cont'd.*):—																
201	No. 40. Sun or Star Azimuths . . .	—	—	60	—	—	—	—	—	25	—	—	100	—	—	—	
202	No. 41. Star Latitude	—	—	60	—	—	—	—	—	50	—	—	100	—	—	—	
203	No. 42. Sun Latitude	—	—	40	—	—	—	—	—	—	—	—	40	—	—	—	
204	No. 43. Sides of Triangles	—	—	10	—	—	—	—	—	100	—	—	—	—	—	—	
205	No. 44 Trigonometrical Heights . . .	—	—	—	—	—	—	—	—	100	—	—	—	—	—	—	
206	No. 45. Latitude, Longitude, Rev. Azimuth	—	—	—	—	—	—	—	—	100	—	—	—	—	—	—	
207	No. 46. Distance and Azimuth . . .	—	—	—	—	—	—	—	—	25	—	—	—	—	—	—	
	CAMP ADMINISTRATION BOOKS:—																
208	Carriers' Book	Gov. Printer	Lagos	1	—	1	—	—	—	1	—	—	1	—	1	—	
209	Cash Account Book	do.	do.	1	—	1	—	—	—	1	—	—	1	—	1	—	
210	Store Ledger, Southern Nigeria Survey . .	0 2 0	Johnston	1	1	1	1	1	1	1	1	1	1	1	1	1	
210a	Store Ledger, Camp	—	—	2	—	1	1	—	—	1	1	—	1	—	1	—	
211	Vouchers, Treasury Form No. 1 . . .	Treasury	Lagos	20	—	20	—	—	—	40	—	—	20	—	20	—	
212	Do. do. No. 5 . . .	do.	do.	10	—	—	—	—	—	—	—	—	—	—			
213	Do. do. No. 34 . . .	do.	do.	20	—	20	—	—	—	40	—	—	20	—	20	—	

ITEM	DESCRIPTION.	PRICE. (Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
	CAMP ADMINISTRATION BOOKS (*contd.*):—																
214	Telegraph Forms, Pads	P.O.	Lagos	2	—	1	1	1	—	2	1	1	1	—	1	—	
215	Railway Warrants, Passengers'	L.G.R.	do.	1	—	1	—	—	—	1	—		1	—	1	—	
216	Do. do. Luggage	do.	do.	1	—	1	—	—	—	1	—	—	1	—	1	—	
	PROFESSIONAL BOOKS:—																
217	Handbook, Southern Nigeria Survey	£0 3 6	Johnston	1	1	1	1	1	1	1	1	1	1	1	1	1	
218	Close's Text book	0 3 6	A. & N.C.S.	1	—	1		—	—	1	—	—	1	—	1	—	
219	School of Military Engineering Notes	—	—	1	—	1	—	—	—	1	—	—	1	—		—	
220	Wilson's Text book	—	—	1	—			—	—				—	—	—	—	
221	Chambers' Logs	—	—	1	—	1	1	1	—	2	—	—	1	—	1	—	
222	Boileau's Co-ords. Tables	—	—	1	—	1	1	1	—	—	—	—	1	—	—	—	
223	Shortrede's Logs	—	—	1	—	—	—	—	—	2	—	—	1	—	—	—	
224	S.I. Handbook, Topographical		—	1	—	—	—	—	—	1	—	—	—	—	—	—	
225	Do. Trigonometrical	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	
226	SURVEY CIRCULARS	Issued	S.N.S.	1	—	1	—	—	—	1	—	—	1	—	1	—	

Item.	Description.	Price. (*Per Doz.)	Firm.	Group Camp.		Field Camp.				Trig. Camp.			Theod. Trav. Camp.		Lev. Camp.		Remarks.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
227	Blotting Paper. Sheets	Secretariat	Lagos	10	—	10	4	2	1	10	4	2	10	—	10	—	
228	Books. Duplicating. Quarto	£0 1 4	A. & N.C.S.	5	1	2	1	1		3	1	1	1	—	1	—	
229	Do. do. Octavo	0 0 9½	do.	3	1	2	1	1	1	3	1	1	1	1	1	1	
230	Boxes. Deed. No. 5	0 16 9	do.	1	—	1		—		1	—	—	1	—	1	—	
231	Do. do. No. 3	0 12 0	do.	1	1	-	1	1		1	1	1	-	-		-	
232	Cases. Correspondence	Secretariat	Lagos	10	—	5	—	-	—	10	-	—	5	-	5	-	
233	Cylinders. Postal. 26 by 1 in. Doz. . . .	do.	A. & N.C.S.	30	—	5	—	—	-	10	—	—	5	-	5	-	
234	Envelopes. O.H.M.S. 15 by 10 in. . . .	do.	Lagos	20	—	10		-	—	10	—	—	5	—	5		
235	Do. do. 8¾ by 4 in. . . .	do.	do.	200	—	100		—	—	200	-		50		50		
236	Do. do. Note	do.	do.	500	—	200	—	—	—	500	—		50	—	50	—	
237	Files. Correspondence. Expanding . . .	0 6 0	Shannon	1	-	1	—	—	—	1	—	-	1	-	1	-	
238	Foolscap. Ruled. Double. Quires . . .	Secretariat	Lagos	5		5				15			3	-	3	-	
239	Do. Plain. do. do. . . .	do.	do.	5	—	5	—	—	—	15	—	—	3	—	3	—	
240	Do. do. Single. do. . . .	do.	do.	10	—	5	—	—	—	15	—		3	—	3	—	
241	Do. do. do. With Die. Quires .	do.	do.	5		—		—	—	—			—	—		—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	GROUP CAMP.		FIELD CAMP.				TRIG. CAMP.			THEOD. TRAV. CAMP.		LEV. CAMP.		REMARKS.
				G.O.	*Draftsman.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*Pupil.*	*C.O.*	*Eur. Sur.*	*Nat. Sur.*	*C.O.*	*Assistant.*	*C.O.*	*Assistant.*	
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
242	INK. Black. Jars	Secretariat	Lagos	2		1				3			1		1		
243	Do. Red. do.	do.	do.	1		1				1			1		1		
244	INK-POTS. Field	£0 2 6	A. & N.C.S.	2	1	2	2	2	1	2	2	2	2		2		
245	PADS. Scribbling. $7\frac{1}{8}$ by $4\frac{1}{8}$ in.	0 2 0*	do.	3	—	2	1	1	—	3	1	1	2		2		
246	PAPER CLIPS. Assorted. No. 700. Boxes	0 0 $8\frac{1}{2}$	do.	2		1				3			1		1		
247	Do. do. L.E.B. Patent. Doz.	0 3 0*	Shannon	1	—	$\frac{1}{2}$	—	—	—	$\frac{1}{2}$			$\frac{1}{2}$	—	$\frac{1}{2}$		
248	PASTE. Stickphast. $\frac{1}{2}$ botts.	0 0 $4\frac{1}{2}$	A. & N.C.S.	3	—	1	1	1		2	1	1	1		1	—	
249	PENHOLDERS	Secretariat	Lagos	3	1	2	1	1	1	2	1	1	1	1	1	1	
250	PEN NIBS. Waverley. Boxes	0 0 9	A. & N.C.S.	3		1	1	1	1	2	1	1	1	1	1	1	
251	Do. Gilt. "J." do.	0 0 5	do.	3	—												
252	PINS. Toilet. Boxes	Current	Locally	2	1	1	1	1	1	2	1	1	1	—	1		
253	SEALING WAX. Sticks	Secretariat	Lagos	3	—	2	1	1	—	3	1	1	1	—	1	—	
254	STAMPS. Rubber. With Pad	?	?	1	—	1	—	—	—	1				—		—	
255	TAPE. Red. Hanks	Secretariat	Lagos	6	—	4	—	—	—	8			3	—	3	—	
256	TWINE. Plain. Balls	0 4 4*	A. & N.C.S.	2	—	2	—			4			1	—	1		

Appendix IV.—List VII. Camp Equipment.

Item.	Description.	Price. (*Per Doz.)	Firm.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils	Remarks.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
257	Bags. Kit. Green Canvas	—	—	1 *b*	1 *a*	1 *b*	1 *b*	1 *a*	*a* All articles marked *a* are necessities supplied by the Government.
258	Basins. Enamel. White. 16 in.	£0 1 5	A. & N.C.S.	1 *c*	—	—	—	1 *a*	
259	Do. Canvas Covers for	0 9 0	do.	1 *c*	—	—	—	—	
260	Baths. Travelling. 38 in.	1 9 2	do.	1 *c*	—	—	—	—	*b* All these articles are necessities which the Surveyor must provide.
261	Do. do. Wicker Lining . . .	0 3 6	do.	1 *c*	—	—	—	—	
262	Bath and Basin. X Canvas	0 19 9	do.	1 *b*	1 *a*	1 *a*	1 *a*	—	
263	Bedding. Improved. X Bed	1 9 0	do.	1 *b*	1 *a*	—	—	—	
264	Do. Cork Mattress	0 8 0	do.	1 *c*	1 *c*	—	—	—	*c* These articles are recommended as useful.
265	Do. Pillows	0 4 0	do.	2 *b*	2 *a*	—	—	—	
266	Do. Pillow Cases	0 0 10	do.	4 *b*	4 *a*	—	—	—	
267	Do. Sheets. Pairs	0 8 0	do.	1 *b*	1 *a*	—	—	—	
268	Do. Blankets. Brown	0 6 0	do.	4 *b*	4 *a*	—	—	—	
269	Do. Mosquito Net	0 18 6	do.	1 *a*	1 *a*	—	—	—	
269a	Do. Do. Rods for . . .	0 10 6	do.	1 *a*	1 *a*	—	—	—	
270	Do. Bed Bag	0 10 3	do.	1 *b*	1 *a*	—	—	—	
271	Do. Name on Bag	0 1 0	do.	1 *b*	1 *a*	—	—	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
272	BEDS. X Pattern	£0 12 3	A. & N.C.S.			1 *a*	1 *a*	1 *a*	
273	BOXES. Chop	Current	S.N.S.	5 *a*	5 *a*	3 *a*	2 *a*	1 *a*	
274	BUCKETS. Canvas	0 4 3	A. & N.C.S.	1 *c*	—	—	—	—	
275	Do. Tin	0 2 0	do.	1 *a*	1 *a*	1 *a*	1 *a*	1 *a*	
276	CARRIERS. Water. Aluminium	1 10 0	do.	1 *a d*	1 *a d*	1 *a d*	1 *a*	—	*d* Increase to 2 if in open country.
277	CHAIRS. Hammock. Folding	0 3 1	do.	1 *c*	1 *a*	—	—	—	
278	Do. High Back. Folding. No. 1	0 5 3	do.	1 *a*	—	1 *a*	—	—	
279	FILTERS. Pump. Berkfeldt. With Stirrup	2 1 0	do.	1 *a c*	1 *a*	1 *a*	1 *a*	—	*c* These Filters are alternative.
280	Do. do. Spare Candles, with Washer and Spout	0 4 10	do.	3 *a c*	3 *a*	3 *a*	3 *a*	—	
281	Do. Drip. 6 Candle. Pasteur-Chamberland	2 12 6	do.	1 *a e f*	—	—	—	—	*f* Only supplied to Group and Camp Officers.
282	Do. do. Spare Candles	0 4 3	do.	3 *a e f*	—	—	—	—	
283	Do. do. Spare Sets of Nipples	0 6 0	do.	1 *a e f*	—	—	—	—	
284	HAMMOCKS	P.W.D.	Lagos	1 *a g*	1 *a g*	—	—	—	*g* 1 in each Camp.
285	LAMPS. Hurricane	0 3 6	A. & N.C.S.	1 *a*	1 *a*	1 *a*	1 *a*	1 *a*	
286	Do. do. Spare Glasses	0 0 3½	do.	1 *a*	1 *a*	1 *a*	1 *a*	1 *a*	
287	Do. do. Spare Wick. yds.	0 0 1	do.	1 *a*	1 *a*	1 *a*	1 *a*	1 *a*	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
288	LAMPS. Lords'. Large	—	—	1 *b h*	—	—	—	—	*h* These Lamps are alternative.
289	Do. do. Small	—	—	1 *b h*	1 *a*	1 *a*	—	—	
289a	MEDICINE CHEST	—	S.M.O. Lagos	1 *a*	1 *a*	1 *a*	1 *a*	1 *a*	
290	NETS. Mosquito. Bell	£0 17 6	A. & N.C.S.	—	—	1 *a*	1 *a*	1 *a*	
291	Do. do. Patrol Tent	0 17 0	do.	—	—	—	*i*	*i*	*i* Issued to Surveyors using Patrol Tents.
292	TABLES. Venesta. Wood	—	—	1 *b*		—	—	—	
293	Do. Picnic. Wood	0 7 9	A. & N.C.S.	1 *a*	1 *a*	1 *a*	1 *a*	—	*j* Headquarters Camp only.
294	Do. X Pattern	0 15 0	do.	1 *b*	—	—	—	—	
295	TENTS. No. 6. Special. 12 ft. × 10 ft. × 9 ft. 4 ft. Walls	19 8 9	do.	1 *j*	—	—	—	—	*k* Group and Camp Officers only.
296	Do. do. Porches for	—	—	1 *j*	—	—	—	—	
297	Do. do. Ground Sheets for . . .	—	—	1 *j*					*l* To Surveyors who are not Group or Camp Officers.
298	Do. No. 6. 12 ft. × 10 ft. × 9 ft. 3 ft. Walls	13 17 6	A. & N.C.S.	1 *a k*	—	—			
299	Do. do. Porches for	1 13 3	do.	1 *a k*	—	—	—		*m* Camp Officers only.
300	Do. do. Ground Sheets for . . .	1 18 0	do.	1 *a k*	—	—	—	—	
301	Do. No. 2. 9 ft. × 7 ft. 6 in. × 7 ft. 6 in. .	9 5 0	do.	1 *a l*	1 *a*	1 *a m*			*n* To N.C.O.'s who are Camp Officers.
302	Do. do. Porches for	1 6 3	do.	—	1 *a n*	—			

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
303	TENTS. No. 2. Ground Sheets for . . .	£1 1 6	A. & N.C.S.	1 *a l*	1 *a*	-			
304	Do. No 1. 7 ft. 6 in. × 7 ft 6 in. × 7 ft. . .	7 8 0	do.	—	-	1 *a*	-		
305	Do. do. Ground Sheets for . . .	0 19 0	do.	—	—	—	-	-	
306	Do. Patrol	3 11 3	do.	—	—	—	1 *a*	1 *a*	
307	Do. do. Ground Sheets for . . .	0 14 3	do	—	—	—	1 *a*	—	
308	Do. Office. 8 ft. square. Lined Yellow . .	12 0 0	do.	1 *a o*	—	—	-	-	*o* Group Officer only.
	UTENSILS, KITCHEN.								
309	COOK'S KNIFE	0 2 0	do.	1 *b*	1 *a*	—	—	—	
310	Do. FORK	0 1 7	do.	1 *b*	1 *a*	—	—	—	
311	Do. SPOON	0 0 4	do.	1 *b*	1 *a*	—	—	—	
312	DISHES	0 0 7	do.	2 *b*	2 *a*	—	—	—	
313	DISH CLOTHS	0 1 3*	do.	6 *b*	6 *a*	—	—	—	
314	FRYING PAN	0 1 10	do.	2 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
315	GLASS CLOTHS. Yds.	0 1 0	do.	6 *b*	—	—	—	—	
316	KETTLE. 6 pint	0 3 6	do.	1 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
317	Do. Sirram. Sets. 3 pint	0 8 6	do.	1 *c*	—	—	-	-	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
318	KITCHEN CLOTHS	£0 0 7	A. & N.C.S.	6 *b*	3 *a*	—	—	—	
319	KNIFE BOARD	0 1 9	do.	1 *b*	1 *a*	—	—	—	
320	MINCING MACHINE	0 8 6	do	1 *b*	1 *a*	—	—		
321	SAUCEPAN	0 2 0	do.	1 *b*	1 *a*	1 *b*	—	—	
322	Do.	0 2 3	do.	1 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
323	TIN OPENER	0 0 5	do.	2 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
324	VENESTA BOX. Fitted for all Kitchen Utensils	Estimate	do.	1 *c*	—	—	—	—	
	UTENSILS, TABLE.								
325	CARVERS	0 3 9	do.	1	1	—	—	—	
326	CLOTHS. Table	0 4 9	do.	4 *b*	2 *a*	2 *b*	2 *b*		
327	CORKSCREW	0 0 9	do.	2 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
328	CUPS. Coffee, and Saucers	0 0 4	do.	2 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
329	Do. Egg	0 0 $3\frac{3}{4}$	do.	2 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
330	DISHES. MEAT	0 1 6	do.	2 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
331	Do. Pie	0 0 7	do.	2 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
332	FORKS. Large	0 0 6	do.	3 *b*	2 *a*	1 *b*	1 *b*		

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
333	FORKS. Small	£0 0 4	A. & N.C.S.	3 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
334	KNIVES. Large	0 0 $8\frac{3}{4}$	do.	2 *b*	2 *a*	1 *b*	1 *b*		
335	Do. Small	0 0 $7\frac{3}{4}$	do.	4 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
336	PLATES. Dinner	0 0 5	do.	3 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
337	Do. Soup	0 0 3	do.	3 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
338	Do. Small	0 0 $2\frac{1}{2}$	do.	3 *b*	2 *a*	1 *b*	1 *b*		
339	POTS. Coffee	0 1 4	do.	1 *b*	1 *a*				
340	Do. Tea	0 1 2	do.	1 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
341	Do. Salt, Pepper, Mustard. Set	0 1 11	do.	1 *b*	1 *a*	1 *b*	1 *b*		
342	SPOONS. Dessert	0 0 $7\frac{1}{2}$	do.	1 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
343	Do. Table	0 0 10	do.	1 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
344	Do. Tea	0 0 $3\frac{1}{2}$	do.	4 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
345	Do. Salt	0 0 $3\frac{1}{2}$	do.	1 *b*	1 *a*	1 *b*	1 *b*	—	
346	Do. Mustard	0 0 $3\frac{1}{2}$	do.	1 *b*	1 *a*	1 *b*	1 *b*		
347	STEEL	0 1 0	do.	1 *b*	1 *a*	—	—	—	
348	TUMBLERS	0 0 3	do.	1 *b*	2 *a*	2 *b*	2 *b*	1 *b*	
349	VENESTA BOX. Fitted to carry all Table Utensils	Estimate	do.	1 *c*	—	—			

Appendix IV.—List VIII. Outfit.

Item.	Description.	Price. (*Per Doz.)	Firm.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	Remarks.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
350	Belts. Leather, Plain. The "Scout"	£0 7 6	A. & N.C.S.	1 *b*	1 *b*	1 *b*	1 *b*	1 *b*	*a* Supplied by Government.
351	Braces	0 1 9	do.	1 *b*	1 *b*	—	—	—	*b* Necessities supplied by Surveyor.
352	Boxes. Tin, Watertight. W.A.	1 16 0	do.	2 *b*	1 *a*	1 *a*	1 *a*	—	
353	Do. Name painted	0 1 0	do.	2 *b*	1 *a*	1 *a*	1 *a*	—	*c* Luxuries.
354	Boots. Mosquito	0 14 6	Made locally	1 *b*	1 *b*	—	—	—	
355	Brush and Comb	0 5 6	A. & N.C.S.	1 *b*	1 *b*	1 *b*	1 *b*	1 *b*	*Note.*—In List VIII. the Chief Native Staff need not get all the items mentioned in Col. V., but must have a complete uniform.
356	Collars. Soft, White. Double	—	—	6 *c*	6 *c*	3 *c*	3 *c*	—	
357	Handkerchiefs		—	24 *b*	12 *b*	12 *b*	12 *b*	6 *b*	
358	Looking-Glass. Camp	—	—	1 *b*	1 *b*	1 *b*	1 *b*	—	
359	Plain Clothes. Flannel Suits	—	—	1 *b*	1 *c*	1 *c*	1 *c*	—	
360	Studs. Bone. Assorted	—	—	6 *b*	6 *b*	6 *b*	6 *b*	6 *b*	
361	Shaving Materials	—	—	1 *b*	1 *b*	1 *b*	1 *b*	1 *b*	
362	Shirts. Flannel. Assorted	—	—	4 *b*	2 *c*	—	—	—	
363	Do. Soft, White. No Collar	—	—	1 *b*	2 *b*	2 *c*	2 *c*	—	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s.	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
364	SHOES. Deck	—	—	1 *c*	1 *c*	—	—		
365	SOCKS. Thick. Pairs	—	—	6 *b*	6 *b*	1 *b*	1 *b*	3 *b*	
366	Do. Thin. Pairs	—	—	3 *b*	2 *b*	—	—	—	
367	SWEATER. Thin	—	—	1 *b*	1 *b*	1 *b*	1 *b*	1 *b*	
368	TROUSERS. White or Grey Flannel	—	—	2 *b*	1 *b*	—	—	—	
369	TOWELS. Bath	—	—	2 *b*	2 *b*	1 *b*	1 *b*	1 *b*	
370	Do. Face	—	—	2 *b*	2 *b*	1 *c*	1 *c*	—	
371	VESTS. Thin	—	—	12 *b*	6 *b*	6 *b*	4 *b*	4 *b*	
372	SPONGES	—	—	2 *b*	1 *b*	—	—	—	
373	TOOTH BRUSHES	—	—	3 *b*	3 *b*	1 *b*	1 *b*	1 *b*	
374	NAIL BRUSHES	—	—	1 *b*	1 *b*	1 *b*	1 *b*	1 *b*	
375	SOAP DISHES	—	—	1 *b*	1 *b*	1 *b*	1 *b*	1 *c*	
376	SOAP. Wright's Coal Tar. Pieces	£0 0 4	A. & N.C.S.	24 *b*	24 *b*	Sufficient	Sufficient	Sufficient	
377	TOOTH POWDER. Tins	—	—	Sufficient	Sufficient	do.	do.	do.	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
	UNIFORM, S.N. SURVEY.								
378	HELMET *d*	—	—	1 *b*	1 *a*	—	—	—	*d* Confined to European Staff and Chief Native Staff.
379	BADGE. Brass. "S.N.S."	—	—	1 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
380	HAT. Felt. Terai, Khaki	—	—	—	—	1 *b*	1 *b*	1 *b*	
381	JACKETS. Roll Collar *d*	—	—	2 *b*	2 *a*	—	—	—	
382	Do. High Collar	—	—	—	—	1 *b*	1 *b*	1 *b*	
383	BREECHES. "Shorts"	—	—	2 *b*	2 *a*	2 *b*	2 *b*	1 *b*	
384	Do. Riding	—	—	1 *c*	1 *c*	—	—	—	
385	Do. Long	—	—	1 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
386	PUTTEES. Pairs	—	—						
387	Do. Spat. Pairs	—	—	2 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
388	GAITERS. Leather. Pairs	—	—			—	—	—	
389	BOOTS. Brown. Pairs								
390	SHOES. Brown. Pairs	—	—	2 *b*	2 *a*	2 *b*	2 *b*	1 *b*	

ITEM.	DESCRIPTION.	PRICE. (*Per Doz.)	FIRM.	European Staff and Chief Native Surveyor and Draftsman.	N.C.O.'s	Native Staff, First and Second Class.	Native Staff, Third and Fourth Class.	Pupils.	REMARKS.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
391	TIES, "S.N.S."			1 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
392	SHIRTS, Bush			4 *b*	1 *a*	2 *b*	2 *b*	2 *b*	
393	SPINE PADS			2 *b*	2 *a*	1 *b*	1 *b*	1 *b*	
394	POLISH, Wren's Outfit	£0 1 6	A. & N.C.S.	2 *b*	1 *b*	Sufficient	Sufficient	Sufficient	
395	Do. Wren's, Spare Tins	0 0 6	do.	6 *b*	1 *b*	do.	do.	do.	
396	SADDLE SOAP, For Boots, Tins	0 0 6	do.	2 *c*	2 *c*	—	—	—	
397	DUBBING or VASELINE, For Boots, Tins	0 1 0	do.	4 *b*	1 *b*	Sufficient	Sufficient	Sufficient	
398	WATERPROOF	1 10 0	do.	1 *b*	1 *a*	1 *b*	1 *b*	1 *b*	
399	UMBRELLA, Rain	0 13 0	do.	1 *c*	1 *c*	—	—	—	
400	Do. Sun	0 10 3	do.	1 *b*	1 *b*	—			

APPENDIX V.

LIST OF SURVEY FORMS.

1. Traverse Form (abolished).
2. Traverse Form (abolished).
3. Traverse Form (abolished).
4. Crown Grant Form (Cadastral Branch only).
5. Barometer Levelling Form (School use only).
6. Requisition Book (Form used in Survey Department in all cases where Stores are required).
7. Computation or Azimuth Form (abolished).
8. Acknowledgment of Meteorological Register.
9. Meteorological Observations (daily).
10. Meteorological Return (monthly).
11. Meteorological Return (monthly).
12. Meteorological Return (monthly).
13. Hints to Meteorological Observers.
14. Meteorological Return (yearly).
15. Traverse Form (for use of Cadastral Branch in those Surveys only which are authorised on a scale of chains).
16. Notice to Property Owner.
17. Lagos Town Survey Query Sheet.
18. Cadastral Survey Weekly Report.
19. Form of Letter to Chief Accountant Lagos Railway.
20. Table I.—Slope Corrections (general use).
21. Barometer Height Computation Form (general use).
22. Theodolite Traverse Co-ordinate Forms (general use).
23. Compass Traverse Co-ordinate Forms (general use).
24. Field Book Number Slip (general use).
25. River Field Book Slip (general use).
26. Traverse Field Book Slip (general use).
27. Village Field Book Slip (general use).
28. Care of Survey Beacons (general use).
29. Tables V. and VI.—For Determining the Differences of Height with the Barometer (general use).
30. Field Sheet Record Slip (general use).
31. Table VII.—Co-ordinates of Projection for 15′ Squares, Scale 1 : 62,500 (Topographical and School Branch).
32. Amplitude Computation Form (Topographical and School Branch).
33. Topographical Survey, Table I.
34. Topographical Survey, Table II.
35. Topographical Survey, Table III.—For Triangulation Computations.
36. Topographical Survey, Table IV.
37. Topographical Survey, Table V.
38. Astronomical Form I.—Time by Altitudes of Sun.
39. Astronomical Form II.—Time by Altitudes of Star.
40. Astronomical Form III.—Azimuth by Sun or Star.
41. Astronomical Form IV.—Latitude by Circum-meridian Altitudes of Star.
42. Astronomical Form V.—Latitude by Circum-meridian Altitudes of Sun.
43. Astronomical Form VI.—Azimuth by Sun or Star with Sideral Time Chronometer.
44. Topographical Survey, Form I.—Computation of Sides of Triangles.
45. Topographical Survey, Form II.—Computation of Trigonometrical Heights.
46. Topographical Survey, Form III.—Latitudes, Longitudes, and Reverse Azimuths.
47. Topographical Survey, Form IV.—Distances and Azimuths.
48. Carriers' Book.
49. Cash Book.
50. B.M., Form I.
51. B.M., Form II.
52. Store Ledger, Southern Nigeria Survey.
53. Store Ledger, Camp.

INDEX.

W. & A. K. JOHNSTON LIMITED, EDINBURGH, GLASGOW & LONDON

r Pillars

Stone or Metal

tations (Stone or Metal) Main

do do Minor

and Intersected Trigonometrical Points

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Wood Posts, Buildings Walls, etc

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500 population Iro

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Camps and farm Huts

Creeks Falls or Rapids

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s sometimes dry

NOTE _

ND NAMES ARE TO BE PRINTED ON THE FIELD SHEETS.ONLY REFERENCE NUMBERS but both Names and Numbers are to be shown in the Auxiliary Sheets

In signs 4 and 5 the apex of the triangle is the fixing

In signs 6 7 and 8 the point is the fixing

In sign 9 the arrow need not be vertical and its point is the fixing

In FIELD SHEETS when Reference Nos are necessary, they will be shown in RED on the LEFT of the sign

In AUXILIARY SHEETS the Distinguishing Mark of the Beacon or Mark will be shown on the LEFT

In all cases the Height of any Beacon or Mark should be printed on the RIGHT of the sign

Sign 12 applies to form lines surveyed by Plane Table and Telescopic Alidade in open country, certain points on them being fixed and the remainder put in by eye

Sign 13 applies to form-lines which have only been fixed where they cross surveyed roads and streams, and by partals

Sign 14 is only used when the form lines have not been surveyed and show hills that are put on the map from hearsay information or from a distant view

HILL NAMES Reference No's in Brown surrounded by a square and a reference table kept in the margin

In signs 15 16 and 17 the height is given on the right

The Red point is the station

In signs 20 and 21 the point is the fixing

Tertiary Surface Levels not usually shown on field Sheets except on partals. They should be freely used on Auxiliary Sheets

Represents a Lock, a Regulator

Church or Chapel without Spire or Tower / Church or Chapel with Spire, do do with Tower / Mosque / Fetish Temple

The figure in brackets denoting that the market is held every 5th day

Steam, Wind, Water

Protestant, Roman Catholic

These letters to follow the name of the town Exact position of building to be shown on map Post, Telegraph, Telephone, Where all three exist

Name to be given if known

Not necessary in small villages

Buildings - On the FIELD and AUXILIARY SHEETS show the main roads through the Village or Town, the positions of Commissioner's Qrs, Chiefs House, Fetish Temple, Church, Rest House, Police Station, P O etc accurately by their proper sign after that show one black square for every 50 inhabitants

Head Quarters of Districts, Towns of Head Chiefs etc

A Black line under a name signifies the Head Quarters of a PROVINCE

H Q (in Red) after a name signifies the Head Quarters of a DISTRICT

A Red line under a name signifies the Town of a Head Chief

Every Town and Village is to be given a reference number in black in a black square and a reference table kept. Numbers are underlined as above

Rivers - Every River is to be given a reference number in Blue surrounded by a square and a reference table kept

Direction shown by an arrow in margin only

Most Streams of class 48 are not surveyed in forest

WATER FEATURES.

Sea Coasts

Wells etc: Permanent Wells, Springs and Ponds; Temporary do do do; Wind Pumps; Bucket Pumps; Pipes Water Supply

Marsh

ROADS.

Roads etc: Main or 1st Class with milestone; 2nd Class or Waggon Road; 3rd do or Cart Track; Bicycle Paths; Footpaths; Hunters trails, farm paths etc; Unsurveyed or approximately surveyed tracks

Telegraph Lines: Telegraph; do along double line Roads; do do single do do

Doubtful Information: Doubtful Positions; do Names; do Roads or Streams

FOREST.

Thick Forest of big trees and heavy undergrowth

Medium forest of scattered big trees & heavy undergrowth

Park Country, generally open with patches of trees and scrub

Scrub with few if any, big trees

CROPS & CULTIVATION.

Mahogany Trees

Cocoa plantations cultivated

Rubber do do

Oil Palms and Oil Palm cultivation

Shea Butter Trees and plantations

Kola Trees and plantations

Grain plantations

Yam do

Cassava do

Coffee do

Cotton do

Cocoa-nut Trees

Other plantations

Railways: Double; Single; Light; Projected

Light Forest of small trees with light undergrowth small patches of grass land

Cliffs

Rocks

Sand

Roads - Und

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